

ALL-NEW SORENTO

THE ROAD IS A STORY. WE ADDED AWD FOR ALL ITS UNEXPECTED TWISTS.



The world's greatest stories won't just show up at your doorstep. You have to go find them. And to do that, you need tools that are capable, like 281 horsepower and all-wheel drive. And tools that are functional, like the Blind-Spot View Monitor and 10.25" touch screen with Surround View Monitor. So, you can find all the stories that are waiting out there, no matter how unexpected. The all-new Sorento X-Line. The World's First Storytelling Machine.



THE GREEN ISSUE MOTORTREND



MUSTANG MACH-E *VS.* TESLA MODEL Y

FORD'S NEW
EV PUTS UP A
STRONG FIGHT



+ LAMBORGHINI'S 807-HP, ELECTRIFIED SIÁN

JUNE 2021
MOTORTREND
GROUP

MAKE THIS FATHER'S DAY SPECIAL



WeatherTech
Ready-to-Wash
system

TechCare®



**Acura Sportscar
Challenge at
Mid Ohio**
MAY 14–MAY 16



Catch every race live* on the NBC Family of Networks

*Schedule subject to change. For details, go to imsa.com/weathertech/2021-schedule/





FloorLiner™

CupFone®

Whether you're bonding over a good ol' fashioned car wash or hitting the open road together, giving the gift of WeatherTech this Father's Day ensures your special day with dad will be memorable.



Made in USA



© 2021 MacNeil IP LLC

WeatherTech®.com

Auto. Home. Pet. Find Your Fit.

1-800-441-6287 or 1-630-769-1500

MOTORTREND

June 2021: The Green Issue



ON THE COVER
It's Time
Electrified cars
from Tesla, Ford,
and Lamborghini
represent a new
world of mobility.
Photo: Brandon Lim

24

COMPARISON

Tesla has a big head start
against EV competition,
but Ford proves it's already
a legit player in the game.



Tests & Drives

24 **ELECTRIC PEOPLE MOVERS**

Tesla Model Y vs. Ford Mustang Mach-E

Two pure electric crossovers face off to determine which is the family hauler to beat. *Miguel Cortina*

36 **WHAT'S MY MOTIVATION?**

Volvo XC40 P8 Recharge vs. Volvo XC40 T5

Same vehicle, different fuel. Kilowatts or gas: Which Volvo performs better? *Scott Evans*

42 **GREEN ON A BUDGET**

Honda CR-V vs. Volkswagen ID4

Two wallet-friendly daily drivers: How the practical hybrid and pragmatic EV compare. *Aaron Gold*

48 **MEET YOU HALFWAY** Mitsubishi Outlander PHEV vs.

Toyota RAV4 Prime

Not ready to give up gas? One of these plug-in hybrids could be your transition relationship. *Christian Seabaugh*



EST. 1949
VOL. 73 NO. 6

MotorTrend (ISSN 0027-2094) June 2021, Vol. 73, No. 6. Published monthly by Motor Trend Group, LLC, 831 South Douglas Street, El Segundo, CA 90245. Copyright© 2021 by Motor Trend Group, LLC; All rights reserved. Periodicals Postage Paid at Los Angeles, CA and at additional mailing offices. **Subscriptions:** U.S. and U.S. Possessions \$18 for 12 issues. Canada \$30 per year and international orders \$42 per year (including surface mail postage). Payment in advance, U.S. funds only. **Postmaster:** Send all UAA to CFS. (See DMM 707.4.12.5); NON-POSTAL AND MILITARY FACILITIES: send address corrections to: **MotorTrend**, P.O. Box 37200, Boone, IA 50037.



— ★ ★ ★ —

You love one-stop shopping because it simplifies your life, and usually saves you money, right? When it comes to insurance, GEICO's your one-stop shop to help you save when you box up coverage for all your needs — like homeowners, motorcycle, boat, RV insurance, and more. Go to [geico.com](https://www.geico.com) to see how easy it is to get great savings all in one spot with GEICO.

GEICO® [geico.com](https://www.geico.com) | 1-800-947-AUTO | Local Office

Some discounts, coverages, payment plans and features are not available in all states, in all GEICO companies, or in all situations. GEICO is a registered service mark of Government Employees Insurance Company, Washington, DC 20076; a Berkshire Hathaway Inc. subsidiary. © 2021 GEICO. 2I_6I96I23I8

FIRST LOOK

If you're going to get stuck somewhere without a paddle, this might be the Canoo to do it in.



Departments & Features

- 10 Editor's Note** Welcome to the Green Issue
- 12 Intake** This month's hot metal
- 20 Technologue** The fuel of the future
- 22 Interview** **Jim Farley** CEO, Ford
- 32 How Electric Cars Work** A primer on how EVs get us from here to there. *Frank Markus*
- 54 Plug and Play** Examining the auto industry's future in the electric age. *Alisa Priddle*
- 60 Tech Trends** The latest advancements to help get the most from your EVs, hybrids, and PHEVs. *Frank Markus*
- 62 Penny Wise** Think a green car has to be expensive? Used hybrids and EVs can be surprisingly affordable. *Alex Kierstein*
- 64 Best of Both Worlds** Drive a timeless classic with an electric powertrain via one of these EV conversions. *Conner Golden*
- 66 Clean Up Your Act** Green technologies can make gas combustion less harmful. *Frank Markus*
- 68 Nothing New Here** A pair of charming electric vehicles born a century ago. *Aaron Gold*
- 81 Big Picture** The electric age is here, but not everything is changing. *Angus MacKenzie*



32



54



60



62



MTGARAGE

Arrival Honda Odyssey **Updates** Honda Civic Si
Kia Soul • Mazda CX-30 • Nissan Sentra
Ram 2500 **Verdict** Mazda 3

72



64



68

STREAM THE NEW TOP GEAR AMERICA ON THE MOTORTREND APP! SIGN UP FOR THE **ALL-NEW** adventures of Dax Shepard, Rob Corddry, and Jethro Bovingdon at [MotorTrend.com/TopGearAmerica](https://www.motortrend.com/topgearamerica)

SKECHERS®

ArchFit®
PODIATRIST CERTIFIED ARCH SUPPORT



FEATURES & BENEFITS

- PODIATRIST DESIGNED SHAPE
- COMFORT ARCH SUPPORT
- SHAPE OF INSOLE WAS DEVELOPED WITH OVER 20 YEARS OF DATA
- MACHINE WASHABLE



**THE ULTIMATE SOLUTION
FOR ALL-DAY COMFORT**

**HOWIE
LONG**

SKECHERS.COM

IT'S TIME TO GO **BEYOND CERAMIC**



@303carcare



@303products

303graphene.com

MOTORTREND

Editorial

Editor-in-Chief Mark Rechtin @markrechtin
Executive Editor Mac Morrison @Mac_Morrison
Int'l Bureau Chief Angus MacKenzie @Angus_Mack
Senior Features Editor Jonny Lieberman @MT_Loverman
Detroit Editor Alisa Priddle @alisapridde
Features Editors Scott Evans @MT_Evans,
 Christian Seabaugh @C_Seabaugh
Editor-at-Large Edward Loh @EdLoh
Associate Editor Eleonor Segura
Manager, Visual Assets Brian Vance
Photography Asset Editor William Walker @MT_dubdub
Associate Photographers Renz Dimaandal,
 Brandon Lim, Darren Martin
Managing Editor Rusty Kurtz
Senior Copy Editor Jesse Bishop @thejessebishop
Copy Editor Claire Crowley

Technical

Technical Director Frank Markus @MT_Markus
Road Test Editor Chris Walton
Associate Road Test Editor Erick Ayapana @Erkayapana
Road Test Analyst Alan Lau

Art

Creative Director Alan J Muir

Contributors

Correspondents Jethro Bovingdon, Mike Connor,
 Randy Pobst, Derek Powell
Photographers Wesley Allison, Evan Klein,
 James Lipman, Kenny Nakajima, Steven Pham,
 Povi Pullinen, Jessica Walker
Artists Avarvarii Illustration, Paul Laguette

MOTORTREND Digital

Director of Editorial Operations Mike Floyd
Content Operations Manager Zach Gale @ZachGale
Editorial Director, Daily Content Erik Johnson
Deputy Editor, Daily Content Alex Stoklosa
Senior Digital Editors Aaron Gold, Conner Golden,
 Greg Fink, Alex Kierstein
Digital Editor Kelly Lin
News Editor Alex Nishimoto @MT_NishiMotor
Associate Online Editors Duncan Brady,
 Alex Leanse, Nick Yekikian
Motor Trend en Español Miguel Cortina @CortinaMiguel
Content Coordinators Courtney McKinnon, Ryan Ono
Senior Production Editor Ryan Whitehouse
Production Editor Erika Pizano
Digital Design Manager Ryan Lugo
Social Media Manager Carol Ngo
Social Media Editor Billy Rehbock

MOTORTREND Original Programming

Head of Programming and Development Mike Suggett
VP, Linear Programming Roger Henry
VP, Digital Programming & Development Gabriel VanHuss
VP, Production David Lee
Executive Producer, Studio Levi Rugg
Head of Production Brett Adkins
Senior Producer Kristin Curtin
Producers Luis Navarro, Michelle Turczyn
Production Manager Melinda Graves
Production Coordinator Christine Dang
Production Finance Manager Til Samaranayake
Director Bradford Alicea
Design Director Mike Royer
Associate Creative Directors Larry Beimel, Jiro Ietaka
Senior Editor Clint Stringfellow
Lead Assistant Editor Brittany Whitesel
Assistant Editors Breeana Kovelman, Yaniv Parsay,
 Christian Taylor, Jonathan Velasques, Kevin Zhang
Senior Post Production Supervisor Matt Frank
Senior Post Production Producer Natalie Lucaccini
Post Production Producers
 Kelly Barnhardt, Branden DeLangis, Mary-Kate Fitzpatrick
Post Production Coordinators
 Alex Adkins, Carson Einarsen

MOTORTREND Auto Shows

VP, General Manager Steve Freeman

MOTORTREND Certified Vehicles

For more information, please contact us at,
 Info@Motortrendcertified.com

**MOTORTREND
GROUP**

Advertising

Detroit 4327 Delemere Court, Royal Oak,
 MI 48073 Tel: (248) 594-5999
 Laurie Felton, Bill Waldman

Los Angeles 831 S. Douglas St., El Segundo,
 CA 90245 Tel: (310) 531-9900
 Chuck Miller, Matt Smith

New York 1180 6th Avenue, 9th Floor,
 New York, NY 10036 Tel: (212) 915-4413
 Ryan Bahoshy, Janet Catallo

Chicago 180 N. Stetson Avenue, Suite 3300,
 Chicago, IL 60601 Tel: (312) 470-3441
 Mason Alwan

Marketing Director

Shawn Higgins

Advertising Coordinator

Yvette Frost

MOTORTREND Group

President/General Manager

Alex Wellen

Group SVP, Sales

Eric Schwab

Head of Editorial

Edward Loh @EdLoh

Head of Operations

Jerry Solomon

Head of Marketing

Kristene Turner

VP, Sales Auto Aftermarket

Matt Boice

SVP, Content Strategy Aftermarket

David Freiburger

VP, Finance/Controller

Shilpa Joshi

VP, Social Media & Content Monetization

Megan Neal

Director, Publishing Systems

Matthew Paige

Any submissions or contributions from readers shall be subject to and governed by Motor Trend Group, LLC User Content Submission Terms and Conditions, which are posted at <http://www.motortrendgroup.com/submissions/>

Subscriptions

E-mail address changes to motortrend@emailcustomerservice.com, write to MotorTrend, P.O. Box 37200, Boone, IA, or call 800/800-6848. Include name, address, and phone number on any inquiries. Occasionally our subscriber list is made available to reputable firms offering goods and services we believe would be of interest to our readers. If you prefer to be excluded, please send your current address label and a note requesting to be excluded from these promotions to Motor Trend Group, LLC, 831 S. Douglas St., El Segundo, CA 90245, Attn: Privacy Coordinator.

Back Issues

To order back issues, visit circsource.com



Copyright 2021 by Motor Trend Group, LLC.
 ALL RIGHTS RESERVED/PRINTED IN THE USA.
 The MOTORTREND trademark is a registered trademark of Motor Trend Group, LLC.

THE NEXT **GENERATION** OF AUTO DETAILING **IS HERE**



SIMPLICITY MEETS SUPERIOR PERFORMANCE

NEW 303® Graphene Nano Spray Coating, a powerful Graphene Oxide formula, provides up to 12 months of protection, sends water flying off paint, wheels, glass and trim, and delivers insane shine to your ride! All in one SIMPLE application! Its unique formula lowers surface temperature of the paint, helping keep water spots at bay.

It's time to go beyond wax, beyond ceramic, and time to become a part of the future - the future of exterior protection - with 303® Graphene Nano Spray Coating.

AVAILABLE AT:



FOR MORE INFORMATION VISIT [www. 303GRAPHENE.com](http://www.303GRAPHENE.com)

Editor's Note

Welcome to the Green Issue

Kermit Was Right

Thank heavens Robert E. Petersen had the forethought to call this magazine *Motor Trend* when he founded it back in 1949, as the age of electric, motor-driven vehicles is finally upon us. Again.

EV 1.0 emerged shortly after the automobile itself, in the late 1800s. Back then the question was open as to what technology should power the newfangled horseless carriage—steam boilers, gas engines, or electric motors. By the time *MT* arrived, the decision had been cemented by 60-plus years of innovation, but the car world still flirted regularly with alternative propulsion propositions (1969 seemed a particularly provocative year); EVs were always humming in the background.

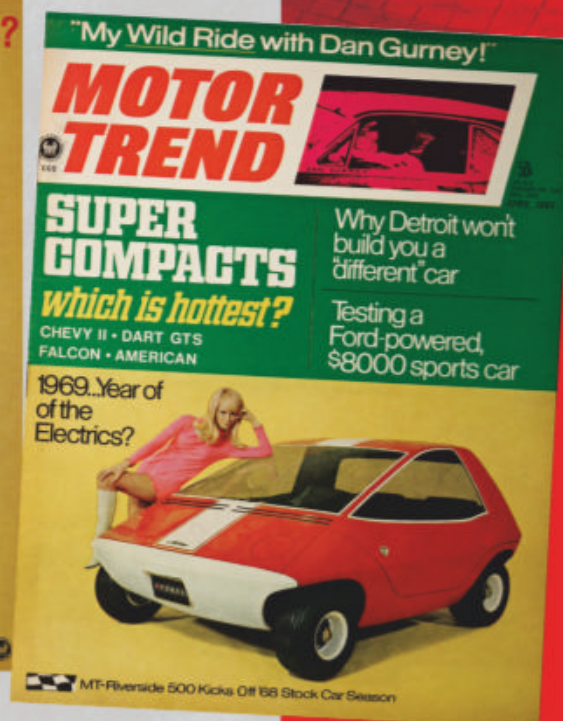
The hum became a roar in November 2012, when we named the Tesla Model S our 2013 Car of the Year. Almost nine years later—more than a complete life cycle for most cars—we are seeing a massive influx of electrified challengers, from names you know and upstarts like Canoo, Drako, and, uh, Lamborghini? (See page 12 for more.)

General Motors (another smartly named enterprise) has been right there, from the first mass-produced electric car of the modern era, 1996's EV1, to our 2017 COTY, the Chevy Bolt EV. In this issue, Frank Markus drives the latest Bolt EUV (page 46), which is longer, smarter, and the second installment of GM's aggressive plan to sell only electric cars by 2035, on the way to carbon neutrality by 2040. But an updated Bolt is only one piece of the puzzle, as you'll read about in Alisa Priddle's industry overview (54); GM is poised to pull off the most Frankenstein move the auto industry has ever seen, by wiring electrodes to the hulking Hummer brand and throwing the EV switch.

It would have been easy to dismiss Ford's announcement of a Mustang-branded EV as a "hold my beer" moment, but for this fact: The Mach-E is shockingly good, as Miguel Cortina finds out in his comparison test against the Tesla Model Y (24). For context on Ford's other EV plans, including the coming electrified F-150, Priddle chats with new Ford CEO Jim Farley (22).

We have many more matchups of brands you know in the pages to follow: Aaron Gold pits VW's ID4 EV against Honda's CR-V Hybrid (42); Scott Evans helps you decide between Volvo's gas and electric offerings (36); and Christian Seabaugh and Eleonor Segura round up a quartet of the latest plug-in hybrids from Ford, Mitsubishi, Subaru, and Toyota (48). Looking for another way to enter the green? Alex Kierstein covers the best used EVs and hybrids (62), while Conner Golden wrangles an amazing array of electric restomods, from budget to high-dollar (64).

Throughout all of this coverage, we offer critical context and counterpoints on the state of hydrogen fuel cells (20),



battery/motor technology (34), the future of internal combustion (66), and new pollution and recycling challenges (60). As Kermit the Frog said, it's not easy being green.

On a related note, this issue marks one year of the *MotorTrend* team working under the unprecedented conditions imposed by COVID-19. On Thursday, March 12, 2020, all of the aforementioned folks and all others on the masthead packed up their laptops and went home for what was supposed to be a daylong feasibility test of working remotely. Little did we know the exercise of Friday the 13th would extend to a couple of weeks and then indefinitely, as the COVID-19 crisis persisted.

But we didn't all work from home all the time. Our photo team, in particular, researched and deployed safety measures that ensured we had a pipeline of car photos for you to enjoy. Our writing team and vehicle testers shifted their approach as auto shows, press launches, and opportunities around the world shut down.

We had to pivot: more reviews, smaller comparison tests. Our priority was to keep up the constant flow of content online, across our many platforms, onto newsstands, and into your hands, with no discernible drop in quality.

I say this not to boast or brag (OK, maybe a just a little) about the dedication and professionalism of the broader *MotorTrend* staff, but because more than a website or a social media meme, magazines are time capsules. Perhaps someday, far in the future, a transportation, pop-culture, or Earth-history fan will wonder how we struggled with the most serious pandemic of our lifetime. And aside from a few lines here and in previous issues, I hope they find no other signs.

I also hope you'll agree we've gotten pretty good at working under these very strange conditions. As they persist, so will we.

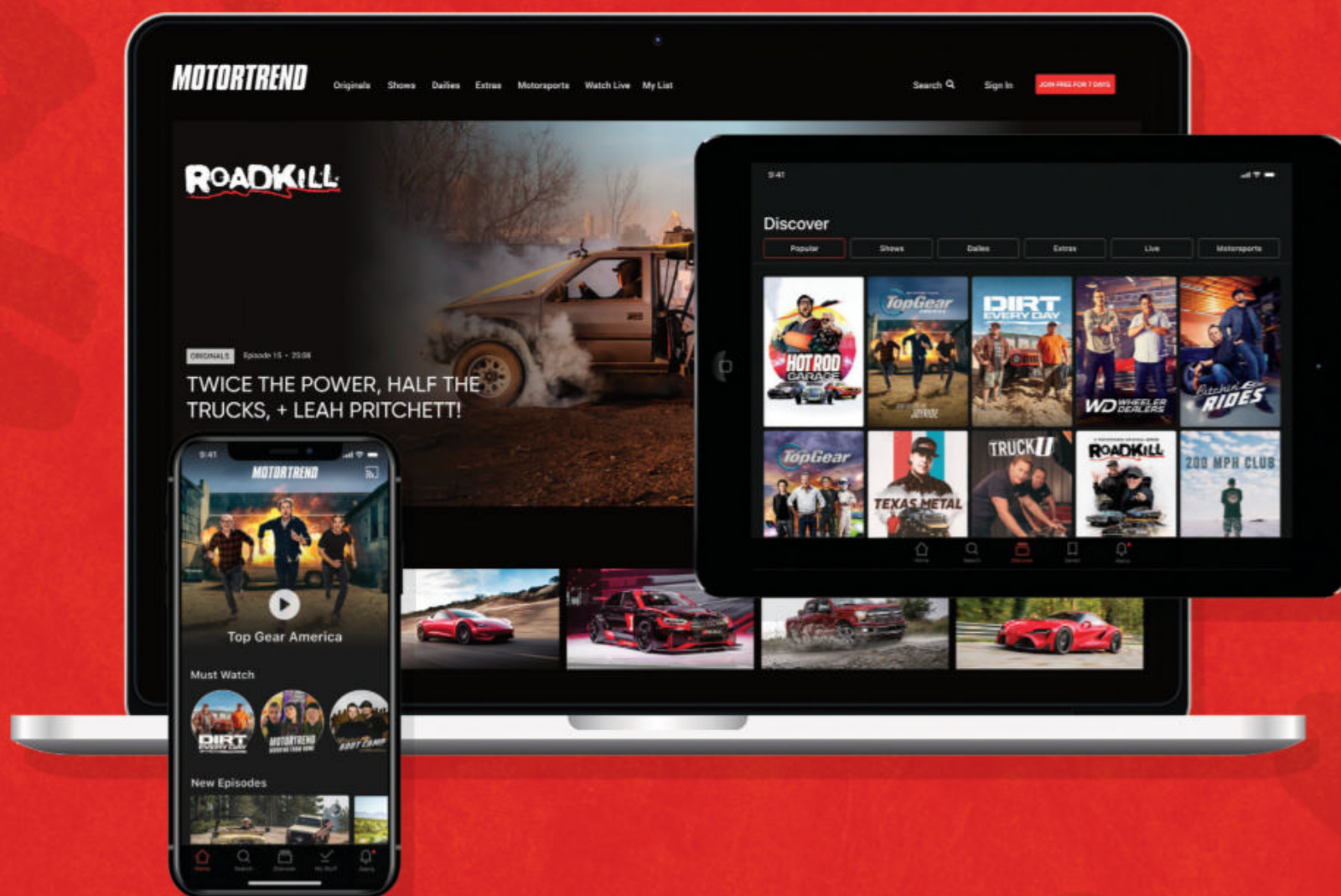
Edward Loh

The automotive industry's infatuation with electric motivation goes back more than a century.

The hum became a roar in 2012, when we named the Tesla Model S our Car of the Year.

Stream the Best Car Shows.

Anytime, Any Device.



Go to:

motortrend.app.link/mt

Trend 6.21

Drako GTE

FIRST DRIVE

WORDS MAC MORRISON & NELSON IRESO
PHOTOGRAPHY DARREN MARTIN



The Drako Is the EV of Enthusiasts' Dreams

Successful software entrepreneurs, lifelong automotive enthusiasts, and Drako Motors co-founders Dean Drako and Shiv Sikand aren't interested in being Tesla. "Tesla only sells one kind of car, a commuter car," Sikand says. "It can be driven cross-country with Superchargers, but at the end of the day it's a commuter car. [We're building] a better-driving car."

That car is the 1,200-hp, four-motor Drako GTE. Ex-Pininfarina design director Lowie Vermeersch reworked its body, based on Fisker Karma architecture, so only the door skins are the same. More important, all the bits you can't see have been overhauled thoroughly. A multi-part battery pack feeds an electric motor at each wheel, and proprietary Drako

DriveOS software aims to deliver a driving experience unlike any other.

The package yields, the company says, "unprecedented yaw control, handling precision, and vehicle stability." Such capability is a critical selling point, given the car's limited run of 25 examples and its staggering \$1.25 million price.

"Wait, what?" you ask. "I can buy an entire pile of sporty EVs for that price!" This is where the broader context surrounding the Drako GTE is key. It is an ambitious project, and Drako's business model combined with the cost of independently developing such a vehicle makes the car a nonstarter at any lower amount.

More important, though, is how Drako aims to go beyond the ideas of automotive one-upmanship, of saving the planet or providing bladder-busting electric range. The development team and executive ranks are stuffed with driving enthusiasts consumed with advancing the automobile as a driver's tool through any available means. "If we could use nuclear power, we would," Sikand says. "Battery electric power is just what is available today [to achieve our performance goals]."

Long, low, and wide, the GTE's form speaks to its dynamic potential, even

before you learn of its prodigious output and chassis layout. Although an engineering degree would be handy to properly understand how it works, once behind the wheel, your hands, feet, and rear end are all you need to know the Drako GTE is something special. Despite its size and mass, the car slithers through corners, nosing eagerly toward apexes before digging in and pushing off with its outer wheels, maximizing acceleration even while continuing to rotate.

The relatively low steering angle required to conquer curves is another of the car's tricks. The GTE and its four-wheel torque vectoring put an end to busy hands, as the chassis simply bends its way into, through, and out of corners. The system responds nearly instantaneously, in part because it eschews the traditional AWD paradigm of a single power source split four ways, instead supplying power





Drako GTE

BASE PRICE	\$1,250,000
VEHICLE LAYOUT	Front/rear-motor, AWD, 4-pass, 4-door sedan
MOTORS	4 x 302-hp/NA lb-ft AC permanent-magnet electric, 1,200 hp (comb)
TRANSMISSION	None (in-wheel motors)
CURB WEIGHT	5,300 lb (est)
WHEELBASE	124.4 in
L X W X H	201.0 x 81.3 x 51.4 in
0-60 MPH	2.9 sec (MT est)
EPA FUEL ECON	Not rated (250-mile range, est)
BATTERY	90 kWh
ON SALE	Now



directly to each wheel with fewer complications. This also unlocks the ability to provide negative torque at any corner, powering a wheel backward to increase stability in emergency situations.

The upshot sees us speed into turns we'd normally brake for, and soon we're accelerating earlier at corner exits. And earlier. And earlier, until we're hitting the go pedal almost before we've even reached the apex, at which point we can no longer tamp down our self-preservation instinct. The GTE feels like it pivots around a post that never changes position, and when its tires break traction, the software works the motors to quicken recovery. We keep waiting for the nose or the rear to give up or snap, as happens with many cars, but they never do.

We are still nowhere near the car's limits; we've simply reached our personal threshold during our first time behind this wheel. It's clear that driving a four-motor car properly requires new skills, as well as dusting off some old ones. Not because you have to work around the car, but because it opens a whole new approach to driving quickly, if not a whole new perspective on automotive physics. Yet the GTE never comes across as a synthetic hero. Spend time learning its limits and how it responds to various inputs, and you can exploit its talents to the benefit of your absolute hedonistic enjoyment.

To put a finer point on things, Drako's DriveOS computer system calculates and communicates each wheel's torque 1,000 times per second based on slip, yaw, steering angle, throttle and brake application, and other factors. The system—and especially its torque-vectoring functionality—is so quick and seamless to respond, there's only one true drive mode, though a center console-mounted switch allows you to play around a bit with the program. But there's really no need. If you want relaxed responses, the car has already noticed by the time you would move your hand to a button. Likewise, if you want to get frisky, the GTE is always ready to go.

Usually by this point in an electric car review, we'd have dived into range, battery size, and perhaps even miles per kilowatt-hour. Those thrilling stats are mostly beside the point with the Drako GTE, but we will say its 90-kWh battery pack provides enough range to do a 20-minute track session while remaining within its sweet-spot charging window of 30 to 90

percent. And with 150-kW fast charging, it can be back at the top of that window in as little as 20 minutes, which is plenty quick for any track day. The pack itself is fairly standard in terms of cell type and chemistry, but Drako Motors engineered a unique method for liquid cooling it to help ensure performance and safety.

Although the production GTE remains in final development (the first delivery is scheduled for this year) and the prototype has a few rough cosmetic edges, it's undeniable this is a special car. Not just due to its gorgeous bodywork, its monstrous power, or even its phenomenal four-motor dynamics, but also because this is the first electric car we've driven that truly feels like a new kind of vehicle. Cars like the Tesla Model S, Porsche Taycan, and Polestar 2 are great in their own ways, but they all deliver the same sort of experience we've known for the past century, just powered by electricity.

In fact, the Drako GTE is so fundamentally different, for now forget about the price, the technical ins and outs, or whether 25 wealthy early adopters will "get it" enough to put one in their garages. Whatever the future holds for the car and the company, what really matters is the Drako GTE and its engineering approach provide a precious gift to enthusiasts who might fear a coming world full of soulless electric appliances: hope.



Intake

2021 Lamborghini Sián **FIRST DRIVE**

Lambo's Most Powerful Road Car Ever Is No Average Hybrid

The 2021 Lamborghini Sián will catapult to 60 mph in 2.8 seconds and hit 220 mph, leaving in its wake a shock-and-awe wall of sound from its 6.5-liter naturally aspirated V-12. The Sián is long and low and extreme, with a menacing, almost alien road presence that signals its status as a tarmac predator ready to pounce and devour random Ferraris. The Sián packs an 807-hp punch, making it the most powerful Lamborghini road car ever built. It's also Lamborghini's first hybrid.

Lamborghini will build just 19 roadsters and 63 coupes, to celebrate the company's founding in 1963. The coupe costs \$2.64 million, and 15 are coming to the U.S. No word yet on price for the roadster, U.S. versions of which will arrive between May and December. Finally, its name was

amended after its debut to include "FKP 37" to honor late VW Group Chairman Ferdinand Piëch, who was born in 1937.

Hybrid hypercars are nothing new. We tested Porsche's 918, McLaren's P1, and Ferrari's LaFerrari—200-plus-mph hybrid-powered rockets all—way back in 2015. The Sián is late to the party, but it unveils a technology claimed as the next big thing for high-performance hybrids: the supercapacitor.

A supercapacitor stores electrical energy, but unlike a battery, it doesn't bind the energy in a chemical reaction. Instead, the supercapacitor stores electricity in a static state. That means it can recharge almost instantly and can hold more power than a typical lithium-ion battery of the same size. It also has a longer working life than regular batteries and functions at temperature extremes that flummox most battery chemistries.

There are downsides. Supercapacitors self-discharge more rapidly than lithium-ion batteries, losing 10 times more energy over a 30- to 40-day period. They are also much more expensive than batteries, and their cells have a lower voltage. But automakers are pursuing the tech, and some analysts predict the global automotive supercapacitor market will be worth \$7 billion by 2028.

The Sián's supercapacitor is three times more powerful than a battery of the same weight and three times lighter than a

battery producing the same power. It snug-gles in the bulkhead between the cabin and engine compartment and powers a 34-hp motor mounted to the side of the car's automated manual transmission. That's not much power from the motor—even a Prius Prime packs 95 horses of pure electric power—but the Sián's hybrid setup isn't designed to allow the car to glide with its engine shut down. Indeed, there is no pure EV mode; instead, the motor provides torque fill at speeds up to 80 mph.

The Sián shares much of the Aventador's mechanical hardware, including its seven-speed single-clutch transmission. This design demands a rapid ignition cut during gearshifts to reduce the torque loads in the transmission. During normal driving in the Aventador's most amenable drive mode, Strada, this sometimes results in herky-jerky progress; in max-attack Corsa mode, it delivers shift shock that feels like you've been hit in the back of your head with a shovel.

But not in the Sián. Even in Corsa, with the transmission in its manual mode, your right foot buried and the V-12 bellowing, the Sián slips crisply from gear to gear, the little electric motor stepping in to smooth torque interruptions. In Strada, with the transmission set to automatic, the big Sián will mooch along much more calmly and contentedly than the Aventador. You can watch the boost and recharge displays dancing up and down on the



The Sián is fundamentally an Aventador SVJ with more radical exterior styling and a redesigned interior. Oh, and a wicked hybrid powertrain.

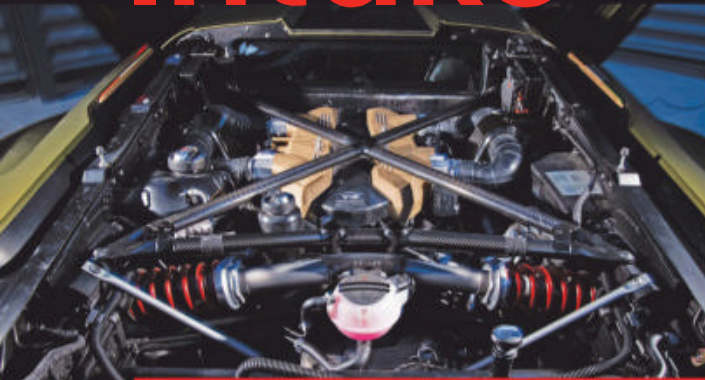
Trucks haven't changed much in the past one hundred and twenty years. Sure, they come wrapped in an assortment of rugged-looking sheet metal and stuffed full of features to keep your mind off the harsh ride, but if you were to strip all of that away, you would be left with the same basic structure. So, when **Honda** decided to build a truck for the 21st century, we used a lightweight unibody frame instead of the harsh-riding body-on-frame design needed only for heavy-duty towing. We also scrapped the live rear axle—a design that's been around since horses actually powered your ride. This makes the Ridgeline the only truck in the segment that **powers** over rough and uneven terrain with an independent rear suspension, which reduces how much the occupants inside get bounced around by allowing both sides of the suspension to operate on their own. Both of these features give the Ridgeline **a** composed driving experience no other truck can come close to. After all, who said rugged had to be rough?



We then took another giant leap away from truck tradition with the development of our intelligent Variable Torque Management™ (i-VTM4®) all-wheel-drive system. You read that right: The Ridgeline is the only truck with standard all-wheel drive rather than four-wheel drive. We didn't do this for the sake of simply being **different**. We wanted drivers to trust that each tire was performing exactly how it should be, given the **kind** of terrain it was driving over at all times. So instead of pulling a lever or pressing a button to engage all four tires, we designed the i-VTM4 with a system of wet clutches that constantly split torque between the wheels, sending up to seventy percent of the engine's power to the rear axle and then sending up to one hundred percent **of** that power to the left or right wheel, so it's available where it can be used best—instantly and seamlessly. All this makes the Ridgeline the greatest advancement in truck design since it all began, and it shows in every mile of every **journey**. This is how Honda does rugged.



Intake



2021 Lamborghini Sián

PRICE	\$2,640,000
LAYOUT	Mid-engine/motor, AWD, 2-pass, 2-door coupe
ENGINE	6.5L/774-hp/531-lb-ft DOHC 48-valve V-12 plus 34-hp/26-lb-ft electric motor; 807 hp (comb)
TRANSMISSION	7-speed auto-clutch man
CURB WEIGHT	3,350 lb (mfr)
WHEELBASE	106.3 in
L X W X H	196.1 x 82.7 x 44.6 in
0-60 MPH	2.8 sec (mfr)
EPA FUEL ECON	Not yet rated
ON SALE	Now

touchscreen display as the supercapacitor first discharges to feed the motor, then instantly recharges—ready for more. Lamborghini claims the hybrid system makes the Sián more than 10 percent quicker in its lower gears than an Aventador SVJ, increasing traction force by 10 percent in third gear and shaving 0.2 second from the 30–60-kph (19–37-mph) acceleration time. In higher gears, the electric motor increases traction force by more than 20 percent, clipping 1.2 seconds from the 70–120-kph (44–75-mph) time. For now, we’ll take Lambo’s word for it. Let’s just say the Sián feels brutally, epically quick.



Beneath all the sound and fury is a chassis that, dare we say, feels grown up. Early Aventadors oozed menace, with a wayward demeanor that demanded total attention through fast corners and brakes that went to lunch if you worked them too hard on a track. But with each iteration since, Lamborghini engineers have poked the beast back into the cage. The long, wide Sián still fills a road, but both ends of the car know each other. The talkative steering is pin sharp, the ride taut. You know what all four wheels are up to, all the time. And you can trust the brakes.

The Sián is better mannered than an Aventador, but it’s as intensely visceral an experience as you expect a flagship Lamborghini to be. New titanium inlet valves and changes to the engine management system mean the 6.5-liter V-12 punches out 774 hp at 8,500 rpm on its own, the most ever for a Lamborghini road car. With no turbos to dull the response or muffle the noise, the V-12 is glorious above 6,500 rpm; it’s brilliantly alert and ready to give it all, right to the redline. The world will be a grayer place when emission controls and fuel economy regulations consign this engine to history.

Yes, the Sián is a hybrid, though the system fundamentally solves a drivability issue in an aging but still charismatic powertrain. The supercapacitor tech is fascinating, right on brand for Lamborghini, and not without promise: Tesla spent \$218 million acquiring supercapacitor firm Maxwell Technologies in 2019. The Sián proves the words “Lamborghini” and “hybrid” are likely to get even better acquainted in the future. **Angus MacKenzie**



MIKE CONNOR

MT CONFIDENTIAL

There were puzzled pundits aplenty when new Jaguar Land Rover boss Thierry Bolloré announced, as part of Jaguar’s transition to a full electric brand by 2025, that the forthcoming XJ sedan—due to be revealed later this year—was axed. That’s because, say our Gaydon sources, many assumed the new XJ was going to be an electric car, built using hardware evolved from the Jaguar I-Pace. Turns out the XJ Bolloré axed was a car built on JLR’s new MLA architecture, a convergence platform that accommodated mild hybrid, plug-in hybrid, and BEV powertrains. There would have been an electric XJ—but there would also have been plug-in and mild hybrid versions, with JLR’s new 3.0-liter straight-six under the hood. Now all new Jags will be built on a bespoke EV skateboard platform that draws on lessons learned from the I-Pace. **Bolloré’s abrupt axing** of the XJ has cost JLR millions, but it’s not a financial catastrophe. As was always the plan, the company will use MLA architecture to underpin future generations of the Range Rover, Range Rover Sport, Range Rover Velar, and the Land Rover Discovery and Defender. It will be joined by a new, smaller convergence architecture called EMA used for the next-generation Range Rover Evoque and Land Rover Discovery Sport. The ability to package a BEV powertrain in these architectures will mean 60 percent of Land Rover’s lineup will be battery powered by 2030. **A new Countach?** Lamborghini is still pondering an Aventador replacement. No surprise, the powertrain is the sticking point: Lambo technical chief Maurizio Reggiani has already conceded the 6.5-liter naturally aspirated V-12 won’t meet the tough new Euro 7 emissions regulations expected by 2025 without significant impacts on its output and performance. In the interim, though, Lamborghini is making sure its big banger goes out with ... a big bang. Rumors out of Sant’Agata Bolognese suggest that 50 years after the Countach LP500 concept caused jaws to drop at the Geneva show, Lamborghini is building a 21st-century Countach using Aventador hardware. Potential customers have reportedly already put down deposits for what will be a \$2.8 million car. **File under “Nice Things We Can’t Have in America”:** Stuttgart sources confirm there will be an All-Terrain version of the new Mercedes-Benz C-Class wagon. No word on powertrains, but all-wheel drive and height-adjustable air suspension will be standard.

THE SIÁN IS AS INTENSELY VISCERAL AS YOU EXPECT A FLAGSHIP LAMBORGHINI TO BE.



Progressive Casualty Ins. Co. & affiliates.



Go wherever the road takes you.

Whether you were born half-man, half-motorcycle
or just born to ride, there's America's #1 motorcycle insurer.

PROGRESSIVE
1.800.PROGRESSIVE | PROGRESSIVE.COM

Intake

FIRST LOOK



2023 Canoo Pickup

Some shapes are intoxicatingly cool. They inspire irrational behavior like signing up to buy, lease, or “subscribe to” a vehicle you have no legitimate need for. This all-electric 2023 Canoo Pickup will be that vehicle for fans of the pickup variants of vintage forward-control vans like the Chevy Corvair Greenbriar (Rampside), Dodge A100, Ford Econoline, Jeep FC, and VW Transporter. It’s not quite Dodge Deora cool, but it’s close.

Those vintage vehicles placed their front seats on top of the front axle, placing ankles out in the crush zone and rendering them deathtraps in a frontal wreck. Rest assured that—like VW’s ID Buzz riff on the microbus—the Canoo “Lifestyle Vehicle” van and Pickup aren’t really forward-control vehicles. Front seats are positioned safely behind the front axle, but the vehicle designs sell the concept hard, with a bit of front overhang and a windshield that touches down way out at the nose’s vertical face.

Canoo’s Pickup shares its basic 112.2-inch wheelbase, control-arm and composite transverse-leaf-spring suspended skateboard platform chassis (as well as its by-wire steering and braking) with the Canoo Lifestyle Vehicle van and MPDV delivery vans. Burlier 265/60R18 tires fill the extended fender flares nicely, and the Pickup is envisioned to use front and rear motors with a combined output rating of up to 600 hp and 550 lb-ft of torque. A rear motor will be standard, presumably matching the van’s

300-hp/332-lb-ft rating.

The all-wheel-drive version shown is rated for 1,800 pounds of payload capacity and a claimed 200-plus miles of range from its 80-kWh battery. Topping it up from empty to 80 percent on a DC fast charger reportedly takes 28 minutes.

Canoo’s extended-cab configuration provides space behind the front seats for a pair of jump seats or other customizations. The rear window rolls down into the bulkhead to accommodate longer loads. Upright van-based, forward-biased seating leaves room for a 6-foot bed within an overall length of 184.1 inches—21.0 inches shorter than today’s shortest pickups.

There’s no word on how Canoo will price its subscription-model products. For now, color us intrigued. Order banks open in the second quarter of 2022, with deliveries beginning in 2023. **Frank Markus**

2023 Canoo Pickup	
PRICE	Subscription only (based on \$35,000–\$50,000 pricing)
LAYOUT	Rear-motor, RWD or fr/rr-motor AWD, 2–4-pass, 2-door truck
MOTOR(S)	300-hp/332-lb-ft rear, or 600-hp/550-lb-ft fr/rr (comb) AC permanent-magnet electric
TRANSMISSION	1-speed auto
CURB WEIGHT	4,450 lb (mfr)
WHEELBASE	112.2 in
L X W X H	184.1 x 78.0 x 75.6 in
0-60 MPH	6.9 sec (mfr est)
EPA FUEL ECON	Not yet rated (200-mile range, est)
ON SALE	2023



REAR VIEW

From the MT Archive ...



50

JUN 1971
PRICE: \$0.50
For *MotorTrend's* first 20 years or so, it was uncommon to see a foreign car on the front of the book. The gorgeous 1972 Mercedes-Benz

450 SL V-8 on our June 1971 cover was one of the rare cars from overseas to earn the honor. We lauded the Benz for its focus on both safety and driving purity—in an era when U.S. automakers insisted consumers could only get one or the other.



30

JUN 1991
PRICE: \$2.95
If the neon colors and questionable words were any indication, we weren’t quite done with the ’80s just yet. The cars in our June ’91 issue were thankfully contemporary, including convertibles like the C4 Corvette, Ford Mustang, and the mighty Geo Metro.



10

JUN 2011
PRICE: \$4.99
With national gas prices once again easily exceeding \$3.00 per gallon, our June issue focused on ways to have your cake and eat it, too. It featured fun, efficient performance cars like the Ford Focus ST and Volkswagen Golf R.

RUN WITH US

AMSOIL delivers next-level power, performance and protection.

Built in the lab so you can feel it on the road.



**AMSOIL
DELIVERS
28%
MORE ACID-
NEUTRALIZING
POWER**

than Mobil 1,*
helping prevent sludge
and keep engines clean.**

**Based upon independent testing of Mobil 1
Annual Protection Full Synthetic 5W-30,
AMSOIL Signature Series 5W-30 in ASTM D2896.
Oils purchased July 2020.



The First in Synthetics®

ORDER FROM
AMSOIL.com

*All trademarked names and images are the property of their respective owners and may be registered marks in some countries. No affiliation or endorsement claim, express or implied, is made by their use. All products advertised here are developed by AMSOIL for use in the applications shown.

Frank Markus

Technologue

What About Hydrogen? The “fuel of the future” may be coming soon.

I’ve subscribed to the theory that “hydrogen is the fuel of the future (and always will be)” for most of my 30 years on this beat, but a confluence of recent developments suggests maybe we’re nearing a tipping point for the universe’s smallest known molecule.

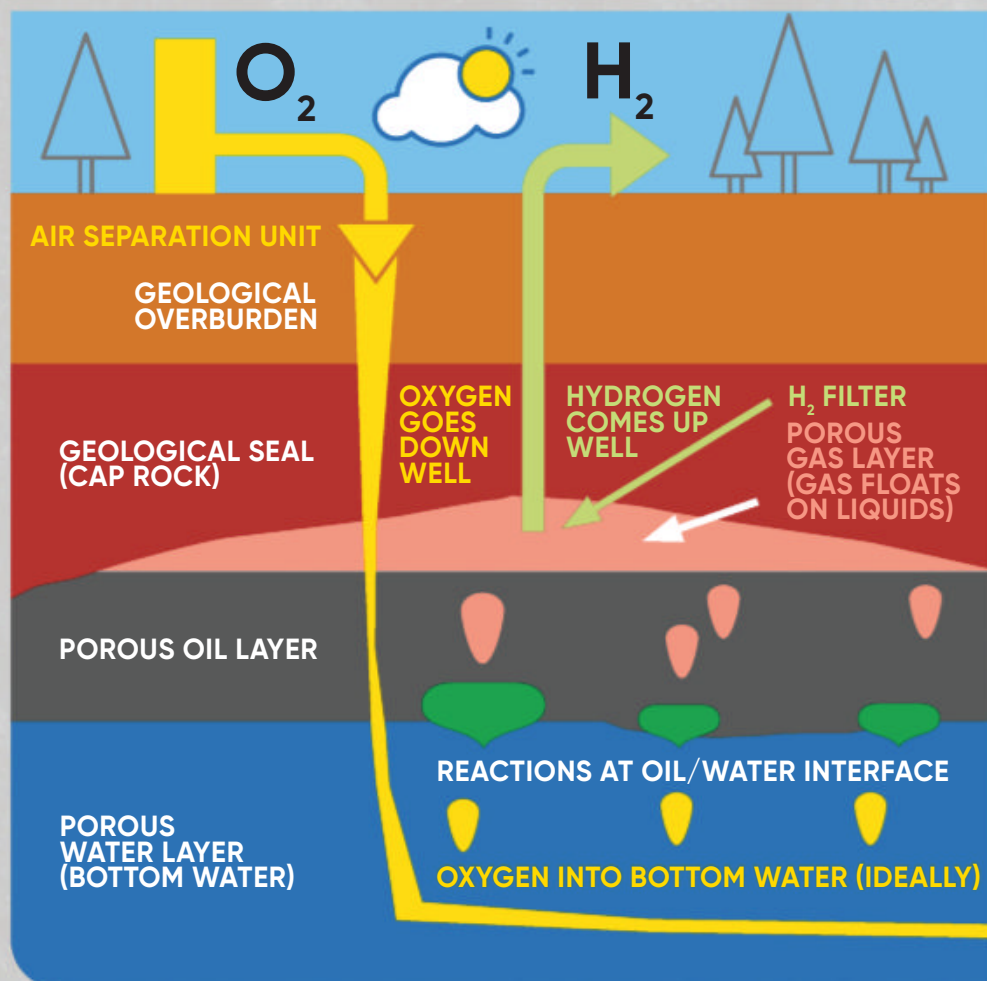
Accelerated development of fuel cells for use in heavy-duty trucking should boost infrastructure and bring the economies of scale needed to hasten light-duty fuel cell electric vehicle (FCEV) adoption. Proliferation of renewable energy is increasing demand for ways to store surplus grid power. One such method: hydrogen. And a novel means of inexpensively producing green hydrogen is emerging.

National Renewable Energy Laboratory senior research fellow and fuel cell group manager Bryan Pivovar tipped me off to this tipping point during a recent panel discussion on *Autoline Detroit*. His lab has teamed with five other national labs on the HyBlend project to investigate blending up to 20 percent hydrogen into the natural gas infrastructure. With said hydrogen produced by electrolysis from surplus solar and wind energy, the project could lower the carbon footprint of the natural gas infrastructure.

The HyBlend project will spend two years assessing the safety and efficiency of such hydrogen/methane blends, as hydrogen has lower energy density and is more explosive than methane. It will also study the effect these smaller H₂ molecules, which are also three times “more permeable,” have on the pipelines themselves. Such blending would create a market for clean hydrogen accessible via the nation’s \$1 trillion natural gas infrastructure while we work to expand our currently meager 1,600-mile hydrogen pipeline network.

Toyota, Hyundai, Daimler, and Volvo all have heavy-duty fuel cell trucks in the works. Initial applications will concentrate on local delivery and port drayage utilizing central fleet refueling, but long-haul hydrogen trucking will follow. During an expected million-mile service life, a long-haul diesel truck typically burns fuel costing three times the tractor’s purchase price. Because FCEV tractors promise far greater efficiency, the powertrain can be considerably more expensive than a diesel engine and still make economic sense over that life cycle. For light-duty vehicles, the life-time ratio of fuel cost to vehicle purchase price is closer to 1:1, so economies of scale from heavy applications are needed to help lower the powertrain cost. But fleet refueling and shared ownership models could also hasten adoption of light-duty FCEVs.

Meanwhile, Proton Technologies of Calgary, Canada, has developed an “ox-injection” means of extracting pure hydrogen from abandoned oil and gas wells in a process that leaves harmful CO₂ and syngas sequestered in the ground. It starts by cryogenically separating liquid oxygen from the air. This oxygen then flash-evaporates at sufficient pressure to force it down into the well, where it bubbles up through the water at the bottom of most wells.



At the water/oil (or gas) interface, it oxidizes, creating heat and steam that powers the gasification, pyrolysis, aquathermolysis, and water-gas shift reactions that liberate the hydrogen. Such underground combustion has assisted oil production for years, with the hydrogen being vented or flared. Now, a palladium alloy catalyst/chemical filter allows only hydrogen to flow to the surface.

Powering the ox-injection operation with hydrogen produced on site keeps things greener and costs low. Estimated production costs are less than \$0.20 per kilogram—well below the \$2.00 to \$3.00 per-kilogram cost of producing hydrogen via steam-methane reformation and way below the \$16.70 per kilo we paid to “gas up” a Toyota Mirai. Ox-injection-generated hydrogen is also cheaper than gas and diesel. (Remember, we didn’t switch from whale oil to crude oil to save the whales.)

Of 50,000 global oil fields, more than half are depleted and/or abandoned, most with half or more of their original oil or gas in place. Best of all: Many of these potential ox-injection sites are close to population centers and energy infrastructure, which simplifies transportation.

Hydrogen may not yet make economic sense as a transportation fuel on its own. Establishing a hydrogen infrastructure capable of storing surplus green energy may not make sense on its own, either. But add them together and tap a network of abandoned oil wells to produce clean, cheap hydrogen, and the fuel of the future’s future starts looking nearer than ever. ■

Initial applications will concentrate on local delivery and port drayage, but long-haul hydrogen trucking will follow.

DAX SHEPARD

ROB CORDRY

JETHRO BOVINGDON



MOTORTREND Presents

Top Gear AMERICA



JOIN US FOR THE
JOYRIDE



BBC

Top Gear



A MOTORTREND ORIGINAL SERIES

ROADKILL



MOTORTREND

Stream All the Best Car Shows!
Go to motortrend.app.link/mt

Interview



Ford's F-150 EV, slated for 2022, will have the electric light mustache look on lockdown.

Jim Farley

Ford CEO

Ford is doubling down on its commitment to electric vehicles, spending \$22 billion over five years on SUVs, trucks, and vans for retail and commercial customers. We talked to Jim Farley, who became Ford CEO on October 1, 2020, for an update on the Blue Oval's efforts to become a dominant e-mobility player.

Ford is coming up with more aggressive electrification plans. How is it shaping up?

We're into the second inning of the e-mobility transformation. It's early days. Allocating capital to some extent is the easiest thing. Our industry is littered with companies making announcements of nameplates they changed, added, or launched this year. And it didn't really have material impact. The proof is in how the customer experience changes and how our brand comes to life in the battery electric space. There are things that aren't changing. We will not be in the commodity transportation business with our second-inning vehicles. We want to electrify our most iconic vehicles. Our [2021 Ford Mustang] Mach-E is on sale now. Our E-Transit will be on sale later this year, and the F-150 gets electrified halfway through next year. We made these decisions a long time ago. The acceleration and spending from 2023 and beyond is where we'll see a real acceleration in nameplates. We have to spend more as we secure our own battery supply and invest in key areas. The most powerful part is the digital experience, a different model of interacting with the customer.

Will truck customers embrace an electric F-150? The revenue pool is enormous. Within that are customers with a duty cycle perfect for electrification. There are two extremes. [The first is] commercial customers with regular fixed routes, happy with depot charging, who need a vehicle with low cost of ownership and 100 percent uptime, as well as features. The second is retail customers with plenty of vehicles for long trips, and they want to drive a pickup that's electrified with software functionality you can't get



“THE PROOF IS IN HOW THE CUSTOMER EXPERIENCE CHANGES AND HOW WE COME TO LIFE IN THE BATTERY ELECTRIC SPACE.”

in a non-electrified vehicle. It is a fully digital vehicle, built Ford tough. We've seen strange designs of fully electric pickup trucks. Soon as they get dirt in them, it's not going to be good.

Do you need more than one dedicated electric platform? Yes. We have multiple platforms. The center point for our businesses is two- and three-row crossovers, pickup trucks, and vans. All have distinct requirements that require a different ground-up battery electric solution. Those vehicles are the next wave. The Mustang Mach-E is the first on our utility platform, but we have more coming, and the platform will continue to evolve.

Are we at a tipping point where EVs are no longer a niche offering? The tipping point in China and Europe has been reached in terms of consideration. In the U.S., half the customers are interested in considering a battery electric vehicle, but when it comes down to intention to buy, we are not at the tipping point. The French, German, and Dutch governments got behind incentives, which made it easier for customers. It also depends on the segment. We have not reached a tipping point in authentic off-roaders because there's really no supply yet. To be a tipping point for intention, the economics have to change.

Is that why Ford will stop selling vehicles with combustion engines after 2030 in Europe but has not set an expiration date in North America? We have a lot more work to do in North America around battery supply. We have legacy issues like labor to resolve. So, allocate the capital to get the product and digital experience out there to make us competitive and attractive, especially on our most iconic vehicles. The rest will follow. We have work to do before we come out with some all-singing-and-dancing commitment in North America. And we don't want it to be an aspiration. We want it to be part of our plan.

Infrastructure is another area that needs to be improved? Yeah. It feels like it's out of our control, but when we launched the Mach-E, we made sure we had the largest charging network. It wasn't easy because we had to put a lot of pieces together—Charge America and other ecosystems. We did partnership deals and wrote our app so when you buy the Mach-E, it shows the 16,000 chargers. It is up to the brand to make it work because [infrastructure] isn't sufficient, but it is on the other side of the invisible line of being just enough. We have to build up the commercial side. **Alisa Priddle**



Trainception: In a Ford stunt, F-150 EV prototypes pulled a train of trucks and an actual train.

Your Say...



WRITE US AT: 831 S. Douglas St.
El Segundo, CA 90245
Email us at
MotorTrend@MotorTrend.com



On the Wagon

Opening up the April edition of *MT* felt like any other month. I started reading through the articles one by one until something amazing happened. Not one, not two, but a three-way station wagon comparison?! Do my eyes deceive me, or has Jonny Lieberman just penned the comparison that wagon lovers like myself have been dreaming of for years?

My love affair with station wagons didn't begin until I picked up a used 2006 Dodge Magnum RT with, you guessed it, a Hemi, baby! Friends scoffed at it, punk teenagers chided me ... all until I blew their doors off with my family hauler. Station wagons, specifically ones boasting more than 400 ponies, are the unsung heroes of the suburban landscape. Yes, minivans are practical and feature-packed, but at the end of the day who wants to drive one, or be seen driving one?

My Magnum can haul 4x8 sheets of plywood home from the local hardware store while still performing burnouts on demand. Jonny references the Cadillac CTS-V wagon, which has always been on my bucket list to own. But with the introduction of these three new players in town—the Benz, Porsche, and Audi—I may need to update that list and up my wagon game. Thank you, Jonny, for shining a light on this overlooked segment. You made my day.

Darin Mobley
Marengo, Illinois

Shopping for Value

Rather than taking pride in winning the 2020 Best Driver's Car with the Huracán Evo, Lamborghini should feel embarrassed for just edging out the Ford Mustang Shelby GT500 costing well more than \$200,000 less. Perhaps doubly so, given Randy Pobst ranked the Shelby No. 1 and the Huracán No. 4. I doubt I'm alone in my belief the Shelby's value makes it the real winner.

Greg McCarty
Buda, Texas

Fears About Infrastructure

Bentley goes all in on electric ... by 2030. As with all the others rushing to go all electric, I have a big concern: As we found out recently in Texas, the power grid was not up to it all. With no nuclear expansion, same for coal, wind will not be

reliable enough to support the increased demands of electric cars. Neither will solar. If the cars are all there in 2030 or even 2035, demanding capacity for charging, I fear the cost of satisfying their needs will also drive up residential rates as well as commercial rates for businesses, and we will just be back to where we are paying today for gas. I don't think the infrastructure will be ready for it when the cars are all here for customers to buy. Want a peek at what I mean? We still drive today on 1960s-vintage two-lane interstates.

Marv Melsha
Hilton Head, South Carolina

What happened in Texas is tragic, but it appears unique to the Lone Star State, especially considering how quickly its neighboring states returned to normal. Regardless, we agree—our leaders in Washington need to pay more than just lip service to revitalizing American infrastructure and preparing it for our future.—Ed.

Reader on Location

This month's Reader on Location is **Brian Houts** of Maple Grove, Minnesota, who brought us along on a cross-country ski trip. He says: "One of the few things you can do during a pandemic is be outside. I've been a cross-country skier for many years now and just completed my 15th American Birkebeiner in Cable/Hayward, Wisconsin. The 'Birkie' is the largest cross-country ski race in North America, with more than 8,000 skiers competing each year in both 'skate' and 'classic' techniques. It was a different experience this year as many skied 'virtually' from their own locations. But with a group of friends, we still went to the Birkie and completed the race on site, 45 kilometers through the woods and over challenging hills. It's an amazing experience and should be on everyone's bucket list."

"I've been a *MotorTrend* subscriber since 1990 and thought it was about time I submitted one of these. Thanks, and best wishes. Love the magazine!"

We realize no one is traveling much these days, but if you want to be our next Reader on Location, email a photograph of yourself with an issue of MT and 50–100 words on how you're fostering your love of cars from home to motortrend@motortrend.com. You could see your photo and story in a future issue.—Ed.

All-new with military know-how

Meet Valentine One® Generation 2

"It's about range superiority. I told my engineers, 'We want the best radar-finding engine this side of the military.'"

For civilian users, V1 Gen2 is a break-through on range."

— Mike Valentine



All-new
circuitry with

SAW D²L



Valentine Gen2 One®
RADAR LOCATOR

www.valentine1.com
1-800-331-3030

Valentine One Generation 2 is a registered trademark of Valentine Research, Inc.

©2021 VRI

COVER STORY

THE NEXT

WORDS MIGUEL CORTINA
PHOTOGRAPHY
BRANDON LIM



NORM

Elon Musk's approach to running a company is anything but conventional. But whatever you might think of him or his strategies, there's little doubt of his indelible impact across multiple industries, including aerospace, personal technology, and, yes, automotive.

His vision is a central reason Tesla has come to dominate today's EV market despite—or perhaps because of—its relative lack of history or legacy. Yet in just 18 years, the electric car manufacturer has gone from producing small-volume baubles like the original Roadster to pumping out hundreds of thousands of mainstream crossovers and sedans like the Model Y and Model 3. Of course,

Tesla's vehicles are only part of the story. The history books are likely to give Musk and his firm just as much credit for getting the general public geeked about EVs—and sending nearly every other company scrambling to build them as a result.

Tesla is certainly a large reason the Ford Mustang Mach-E exists. Originally conceived as a front-drive, Fusion-based electric crossover under former CEO Mark Fields, the Mach-E was reshaped when new CEO Jim Hackett underscored its importance by telling executives the “heart of the company's on trial here.”

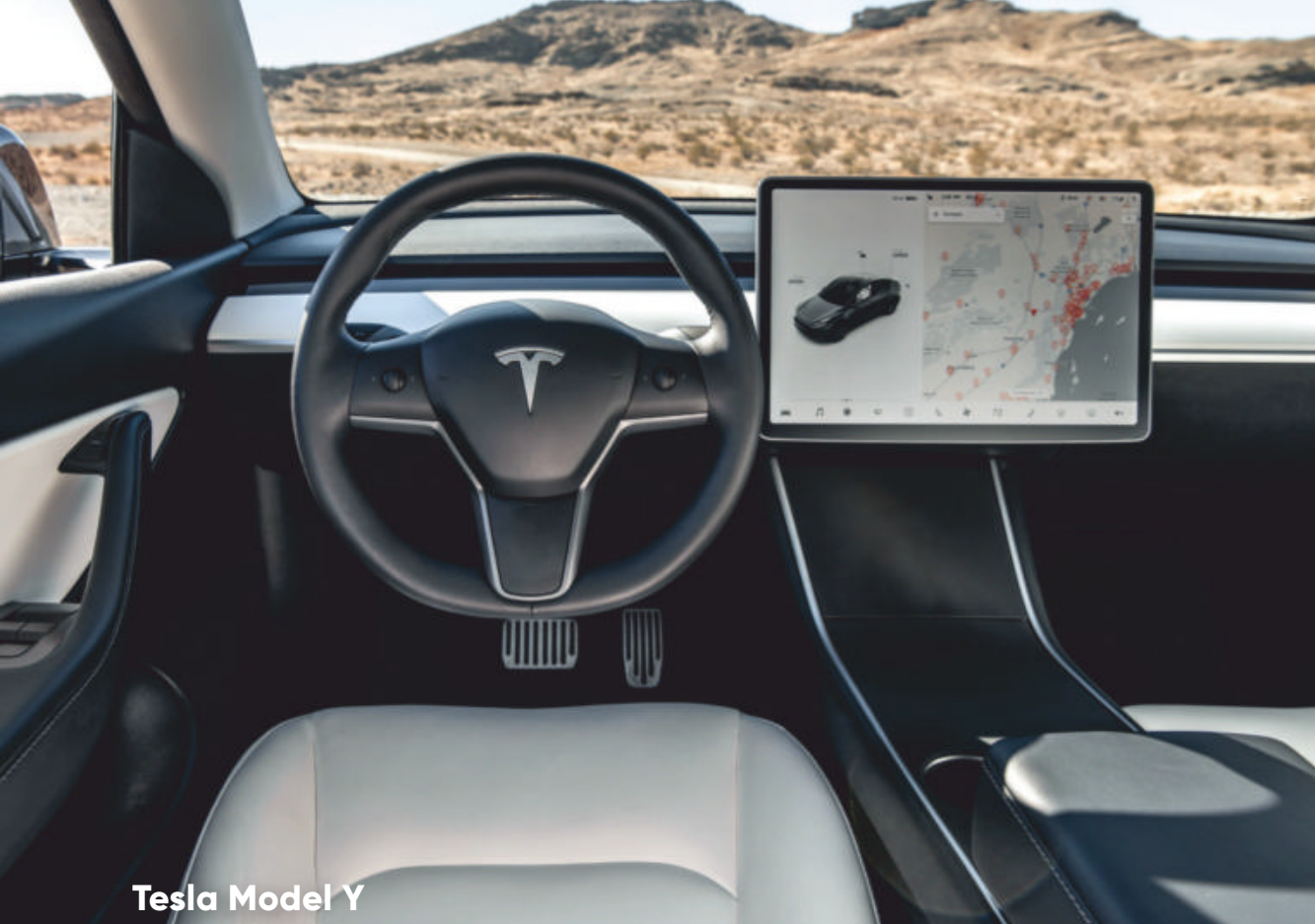
Jim Farley, who succeeded Hackett as CEO but was then Ford's president of global markets, steered the project in the direction of the Mustang brand, which clicked with designers and engineers. The vehicle added rear drive and targeted 300

miles of range, and although the final product isn't a carbon copy of the Model Y, you can tell which vehicle was in Ford's sights.

Our Model Y and Mach-E test cars are closely aligned in terms of performance, range, and size. Our Model Y Dual Motor Long Range is a 2020 model sourced from our friend Richard Hak at Precision One Design; its novel, disparate front and rear motors make 384 hp and 375 lb-ft of torque combined, and it's EPA-rated for 316 miles of range (that rises to 326 for 2021). Power is transmitted through a single gear ratio at each end, providing all-wheel drive. Its base price is just shy of \$52,000, but with the \$10,000 Autopilot option, paint, and interior options, the final sticker rings in at \$63,190.

The 2021 Mustang Mach-E 4x shares the Tesla's same basic setup—front and rear electric motors, two single-speed automatics, and all-wheel drive. Powertrain output stands at 346 hp and 428 lb-ft, and the EPA states it can travel 270 miles on a single charge. This model starts at \$55,800, with a few additional bits elevating our tester's price to \$56,450.

**ELECTRIC SUVs ARE
PROLIFERATING APACE,
AND WHICH ONE RULES
THE ROOST COULD
CHANGE BY THE DAY**



Tesla Model Y

Borrowing lines from other Teslas, the Model Y's minimalist interior looks elegant. It's also roomy—whether we talk about cargo or passenger space.



Those interested in the Mach-E will be pleased to know it is still eligible for federal tax incentives; Tesla has sold too many vehicles for its offerings to qualify under existing federal regulations (though legislation introduced in February could change that).

In the end, will the Blue Oval's electric SUV have the goods to take it to Tesla? Or is the Model Y still king of the heap? To find out, we gathered examples of each, drove them back to back, examined the charging experiences, and poked and prodded their interiors.

The Drive

Although the pair knock noggins in the same segment, they approach their missions differently. The Mach-E's ride, for example, is more polished and plusher than the Tesla's. "On smooth streets, the Model Y is a dream, with an excellent ride and amazing performance," head of editorial Ed Loh said. "On bad pavement, however, its crashing grates, tossing head and belly." The Ford's dampers deliver a settled and controlled ride in all



situations, quickly dissipating vibrations over even heavily broken pavement. It's clear which was developed in Michigan, a state well known for its awful tarmac.

The Californian of the duo, the Model Y, shone on our drive route covering the twisty roads overlooking Southern California's Palos Verdes Peninsula, but so did the Ford. Both keep body roll nicely in check, thanks in part to the underfloor placement of their heavy battery packs. Still, the Mach-E is just a tiny bit more controlled; credit its slightly lower overall height. But the flip side is that the Model Y offers more ground clearance (6.6 inches versus 5.8) and a higher, more commanding driving position.



Although the Ford looks low and lean, and both of these EVs are certainly powerful and sporty, the Model Y is the one that feels quicker in use—and actually is quicker at the test track. The Tesla's power delivery is more linear and easier to modulate compared to the somewhat overeager Mach-E's; we sprinted the Model Y to 60 mph in 4.1 seconds, 0.7 second quicker than the Mach-E. That illustrates how easily the lighter Tesla's 19 percent weight-to-power advantage overcomes the torquier Mach-E's slimmer 3 percent weight-to-torque edge.

The Mach-E offers three chassis modes: Unbridled (what most automakers call Sport), Engage (Normal), and Whisper

"ON SMOOTH STREETS, THE MODEL Y IS A DREAM WITH AMAZING PERFORMANCE."





Ford Mustang Mach-E

The Mach-E's cabin is different from what we've seen from the Blue Oval, but its modern look still incorporates parts from other Fords, like its rotary gear selector.



(Comfort). The steering weights up to deliver an approximation of sportiness in the first two, but no matter which mode you choose, the helm is accurate, quick, and predictable. Power delivery also changes depending on the mode, with the more aggressive accelerator maps in Unbridled and Engage delivering more off-the-line punch. Whisper takes a more linear approach. One-pedal driving can be turned on or off in any mode; while some love its aggressive regenerative braking and actual brake effect when active, others might find it too eager.

Unlike the Mach-E, the Model Y allows drivers to individually mix and match settings for acceleration (Chill, Standard, and Sport), brake feel (Standard and Low), and steering (Comfort, Standard, and Sport). The Tesla's Sport steering doesn't feel as heavy as the Mach-E's in Unbridled mode, but it does add noticeably more resistance in comparison to Comfort. The same is true across the board—none of the Model Y's settings are transformative or particularly aggressive, but the customization allows individual drivers to find their personal sweet spot a little easier than in the Ford.

Speaking of sweet, Tesla's Autopilot hands-free driving system continues to be among the best driver-support setups available today, even if its name remains misleading. (It's not a full self-driving system by any stretch, as you must remain alert and ready to grab the steering wheel at any time.) With Autopilot engaged, the Model Y stays centered in its lane, slows down when appropriate, and recognizes construction areas and traffic lights. On the Mach-E, Ford's Co-Pilot 360 safety suite generally does a good job of interpreting lanes even when the markings

aren't clear. Active Drive Assist, which offers similar functionality to the Tesla, such as hands-free driving (limited to 100,000 miles of mapped highways), will be available later this year.

But Autopilot is the standout winner here. "Active Drive Assist feels relatively low tech in the Mach-E, which is otherwise a technically compelling EV tour de force," Loh said. During our highway drive, the Mustang once failed to apply the brakes when traffic was stopping ahead, and it lacks the advanced features of Tesla's system, such as automatically switching lanes or handling freeway interchanges.

Inside

Tesla started the tech-focused cabin trend, but most electric vehicles now follow that template, including the Mach-E. Although the Ford's interior feels warmer than the Tesla's, it borrows ideas such as hidden air vents and a large central screen while



mixing in familiar Blue Oval parts, like the rotary gear selector. It also adds a second screen to serve as an instrument cluster, which the Tesla lacks. "The cabin offers clean execution for a Ford," Loh said, adding that the gray cloth on the dash and speakers lends a premium feel.

Hop from the Ford to the Tesla, and the Model Y stands out for the ample space it devotes to people and their stuff. "Cargo space is ridiculously impressive, with a deep (3.1-cubic-foot) hidden area under the floor," Loh said. "The seats fold flat, too, and I feel like I could camp in the car." Rear passengers also have more foot- and legroom in the Model Y—the Tesla's front seats are situated on risers in part to provide more toe space to rear riders—and have access to two USB-C ports and their own air vents.

The Mach-E also serves up two USB ports (in this case, one Type-A and one Type-C) and air vents for rear passengers, but there's limited foot room, especially for the middle passenger, and the rear seat has stiffer cushions and is less comfortable overall. The Mach-E's frunk is also a tad smaller than the Model Y's. So although the Mach-E measures objectively larger, the Model Y's space seems more usable.

COMPARISON



Technology

Going beyond the driver assist technology, both of these EVs pile on convenience features, too, with the bulk of them—or all, in Tesla's case—controlled via a central screen. Tesla's is a 15.0-inch horizontal display, while the Mach-E's measures 15.5 inches and is portrait-oriented.

In the Model Y, as with all Teslas, the screen serves as the car's command center, used not only for the usual navigation and audio functions but also for tasks like adjusting the power side mirrors and steering wheel or finding a Supercharger station near you. While having all of these functions in one screen could be distracting, Tesla's clean, simple layout is easy to use and parse at a glance, and the software running the show is quick to respond. Here, perhaps more than anywhere else, is where Tesla's Silicon Valley DNA shines through.

Ford's dual-screen approach is more conventional and simpler to adjust to; its primary display has beautiful high-

resolution graphics, and the screen's real estate truly feels expansive. Wireless Apple CarPlay and Android Auto are standard here, and unlike in the Tesla, there's a

volume knob. Despite these positives, the Model Y wins on usability.

Tesla's interface is designed in such a way that you can split the screen between, say, the navigation map and another function without having to dig through menus; similarly, frequent tasks such as looking for Superchargers are almost always just one tap away. Ford's system will locate chargers and tell you if they're available, but this is buried behind several taps, and the infotainment software takes a little time to load results or respond to requests.

Charging

How long an electric vehicle takes to charge is likely second only to overall range among EV shoppers' considerations, but providing an answer depends on the type of charger, the rating of an EV's onboard charger, and the vehicle's layout and battery size.

Tesla's extensive Supercharger network supplies power at up to 250 kW, with the Model Y's onboard charger capable of accepting that full rate. During our time with Tesla's crossover, we charged the battery from near empty to about 75 percent in 35 minutes using a 250-kW Supercharger—that's about 230 miles of added range. And using the Supercharger was quick and easy: plug in, juice up, and go; the station automatically charges your Tesla account.

The Mach-E has access to a broader grid of public chargers from various companies, but their charging speeds vary. The Mustang Mach-E can receive power at up to 150 kW, which means its fastest rate is slower than the Model Y's. (Think of the kW rating of a charger as akin to the diameter of a pipe.) Using an Electrify America 150-kW DC fast-charging station, Ford says you can add about 50 miles of range in approximately 10 minutes. (That works out to 175 miles in the same 35-minute time frame used above, starting with a similarly discharged battery.) We needed to use a 50-kW EVgo charger, however, so it took us about an hour and 45 minutes to go from 45 miles of range to 215, though that includes time spent using the FordPass app to connect to the charger and dealing with error messages generated by the app. The charger problems weren't the vehicle's fault, but they cannot be overlooked; if a bad app stalls recharging, that affects the ownership experience.



The Mach-E's volume knob adheres to the display and has capacitive "fingers" to work the screen.





Which One Is Better?

Folks considering an electric SUV certainly have compelling choices, and the challengers to Tesla's throne are stronger than ever. "In the stuff that matters—range, performance, packaging, and price—the Model Y's closest competitor comes not from a legacy premium manufacturer like Audi or Porsche, or from fellow EV-only company Lucid—it's Ford," Loh said. "The Mach-E does a compelling imitation of the Model Y, and when you layer on the familiarity of the Blue Oval and the trust it breeds, it's an intriguing package for those unsure about Tesla's build quality, reliability, or the antics of its chief executive."

Ford's first serious EV has put up a hell of a fight, and as more such models hit the streets—and especially as legacy carmakers gain EV experience—Tesla might find itself playing catch-up. Just not today. "When you move from Mach-E to Model Y," Loh said, "you feel like you've taken a step into the future. The impact of that step is smaller thanks to the amazing job Ford's done, but there's no similar sense of wonder when you go from Model Y to Mach-E." The Mach-E has much to recommend it, but the Model Y takes this comparison by a nose—for now. ■

SECOND PLACE

Ford Mustang Mach-E

Ford's impressive first dedicated EV has all the right ingredients. Now it's time to refine the recipe.

FIRST PLACE Tesla Model Y

The Model Y's superior technology, range, charging setup, and interior space carry the day.

The Mach-E is the Model Y's closest competitor. The Tesla is still on top, but that could change soon—a 480-hp Mach-E GT is slated for a late-summer release.

		
POWERTRAIN/CHASSIS	2021 Ford Mustang Mach-E 4x	2020 Tesla Model Y Dual Motor Long Range
DRIVETRAIN LAYOUT	Front/rear-motor, AWD	Front/rear-motor, AWD
MOTOR TYPE	Front/rear: AC permanent-magnet electric	Front: AC induction; rear: AC permanent-magnet electric
POWER (SAE NET)	346 hp (comb)	384 hp (comb)
TORQUE (SAE NET)	428 lb-ft (comb)	375 lb-ft (comb)
WEIGHT TO POWER	13.9 lb/hp	11.3 lb/hp
TRANSMISSION	1-speed automatic	1-speed automatic
SUSPENSION, FRONT; REAR	Struts, coil springs, anti-roll bar; multilink, coil springs, anti-roll bar	Control arms, coil springs, anti-roll bar; multilink, coil springs, anti-roll bar
STEERING RATIO	14.6:1	10.3:1
TURNS LOCK-TO-LOCK	2.7	1.7
BRAKES, F; R	14.3-in vented disc; 12.4-in disc, ABS	14.0-in vented disc; 13.2-in vented disc, ABS
WHEELS	7.0 x 19-in cast aluminum	9.5 x 19-in cast aluminum
TIRES	225/55R19 V XL 103V Continental PremiumContact 6	255/45R19 104W (M+S) Continental ProContact RX
DIMENSIONS		
WHEELBASE	117.5 in	113.8 in
TRACK, F/R	63.5/63.4 in	64.4/64.4 in
LENGTH X WIDTH X HEIGHT	185.6 x 74.1 x 64.0 in	187.0 x 75.6 x 63.9 in
GROUND CLEARANCE	5.8 in	6.6 in
APPROACH/DEPART ANGLE	15.5/25.7 deg	18.0/17.0 deg (MT est)
TURNING CIRCLE	38.1 ft	39.8 ft
CURB WEIGHT	4,807 lb	4,357 lb
WEIGHT DIST, F/R	49/51%	50/50%
TOWING CAPACITY	Not equipped for towing	Not equipped for towing
SEATING CAPACITY	5	5
HEADROOM, F/R	40.4/39.3 in	41.0/39.4 in
LEGROOM, F/R	43.3/38.1 in	41.8/40.5 in
SHOULDER ROOM, F/R	57.6/55.9 in	56.4/54.0 in
CARGO VOL BEH F/R; FRUNK	59.7/29.7; 4.7 cu ft	54.4/22.4; 2.7 cu ft (MT est)
TEST DATA		
ACCELERATION TO MPH		
0-30	1.9 sec	1.8 sec
0-40	2.7	2.5
0-50	3.7	3.2
0-60	4.8	4.1
0-70	6.2	5.1
0-80	7.9	6.3
0-90	9.9	7.7
0-100	12.4	9.3
PASSING, 45-65 MPH	2.3	1.7
QUARTER MILE	13.4 sec @ 103.5 mph	12.4 sec @ 114.8 mph
BRAKING, 60-0 MPH	109 ft	118 ft
LATERAL ACCELERATION	0.85 g (avg)	0.86 g (avg)
MT FIGURE EIGHT	26.2 sec @ 0.69 g (avg)	25.2 sec @ 0.75 g (avg)
CONSUMER INFO		
BASE PRICE*	\$55,800	\$51,190
PRICE AS TESTED*	\$56,450	\$63,190
AIRBAGS	9: Dual front, f/r side, f/r curtain, driver knee	8: Dual front, front side, f/r curtain, front knee
BASIC WARRANTY	3 years/36,000 miles	4 years/50,000 miles
POWERTRAIN WARRANTY	5 years/60,000 miles	8 years/120,000 miles
BATTERY WARRANTY	8 years/100,000 miles	8 years/120,000 miles (70% of original capacity)
ROADSIDE ASSISTANCE	5 years/60,000 miles	4 years/50,000 miles
BATTERY CAPACITY	88 kWh	75 kWh
TIME TO CHARGE (240V)	10.7 hrs	10.0 hrs
EPA CITY/HWY/COMB ECON	96/84/90 mpg-e	127/114/121 mpg-e**
EPA EST RANGE	270 miles	316 miles**
ENERGY CONS, CITY/HWY	35/40 kWh/100 miles	27/30 kWh/100 miles
CO2 EMISSIONS, COMB	0.00 lb/mile (at vehicle)	0.00 lb/mile (at vehicle)
RECOMMENDED FUEL	240-volt electricity	240-volt electricity

*Excluding applicable federal (Ford) or local tax credits
**A similarly equipped 2021 Tesla costs the same, but EPA ratings rise to 131/117/125 mpg-e and 326 miles of range.

THE WAY TIRE BUYING SHOULD BE.™



FREE two-year road hazard protection with most tires
www.tirerack.com/roadhazard

FREE mount and balance with a tire & wheel package
www.tirerack.com/packages

FAST, FREE shipping on all orders over \$50
www.tirerack.com/freeshipping

OVER 1,700 DIFFERENT WHEELS FROM 54 BRANDS



GOODYEAR

KEEP MOVING AHEAD

\$75 BACK
GET UP TO **\$75** ON A SET OF FOUR SELECT GOODYEAR® TIRES.*

+

AN ADDED BONUS OF UP TO **\$75 MORE** WHEN YOU USE THE GOODYEAR® CREDIT CARD.*



Offer Valid April 1 - June 30, 2021

Eligible Tire Lines*

	Base Rebate Amount	Rebate with Goodyear® Credit Card
Assurance ComfortDrive™, Eagle® Exhilarate®, Eagle® F1 SuperCar® Family, Eagle® F1 Asymmetric Family	\$75	\$150
Assurance® MaxLife™, Assurance® WeatherReady®, Eagle® Sport All-Season, Wrangler® All-Terrain Adventure with Kevlar®, Wrangler® Fortitude HT (excludes C-Type)	\$50	\$100
Assurance® All-Season, Assurance® ComforTred® Touring, Wrangler® TrailRunner AT	\$25	\$50

NEW ASSURANCE® COMFORTDRIVE
GRAND TOURING ALL-SEASON

Engineered to deliver the highest level of on-road comfort and refinement, providing drivers of luxury sedans, family cars, and crossovers with a premium experience combined with all-season capability.

EAGLE® EXHILARATE®

ULTRA HIGH PERFORMANCE ALL-SEASON



For drivers of modern muscle cars, performance sedans, and sports coupes who want a tire that delivers handling, acceleration and braking traction that lives up to their vehicle's performance in dry and wet conditions, in addition to light snow capability.

See www.tirerack.com/goodyearoffer for details and rebate form.

Rebate paid in the form of a Visa Prepaid Card or Virtual Account. Card/virtual account is issued by MetaBank®, N.A., Member FDIC, pursuant to a license from Visa U.S.A. Inc. No cash access or recurring payments. Card can be used everywhere Visa debit cards are accepted. Virtual account can be used everywhere Visa debit cards are accepted online, or for phone/mail orders. Card/account valid for up to 6 months; unused funds will forfeit after the valid thru date. Card terms and conditions apply. MetaBank does not endorse or sponsor the Goodyear Credit Card offer.

*Get up to \$75 back by online or mail-in rebate on a qualifying purchase of a set of 4 select Goodyear tires with any form of payment method; plus get an added rebate of up to \$75 more when the purchase is made on the Goodyear Credit Card. Subject to credit approval. Rebate amount varies depending on select tires purchased. Rebates valid on qualifying purchases made from 4/1/21 to 6/30/21. Additional terms and conditions apply. Goodyear Credit Card is issued by Citibank, N.A.

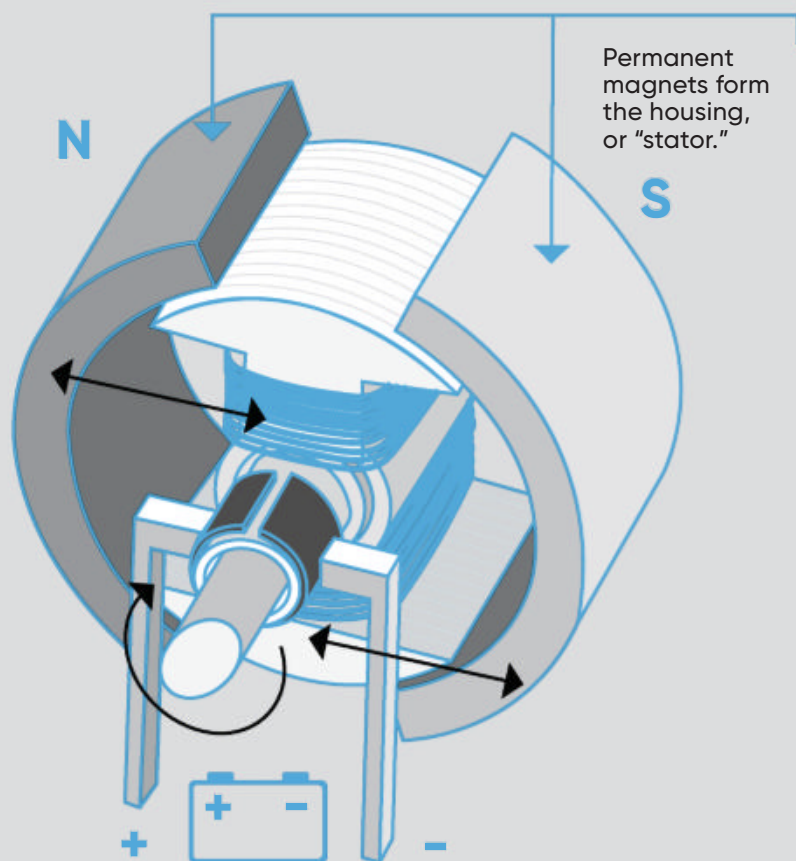
EVS ARE HERE TO STAY. IT'S TIME WE ALL LEARN HOW THEY WORK.

When was the last time you stopped to think about how electric cars actually work? We superfans of the car biz have mostly developed a reasonable understanding of how combustion powertrains work. Most of us can visualize fuel and air entering a combustion chamber, exploding, pushing a piston down, and rotating a crankshaft that ultimately turns the wheels. We generally understand the differences between inline, flat, V-shaped, and maybe even Wankel rotary combustion engines.

Mechanical engineering concepts like these are comparatively easy to comprehend. But it's probably a fair bet to wager that only a minority of folks reading this can explain on a bar napkin exactly how invisible electrons turn a car's wheels or how a permanent-magnet motor differs from an AC induction one. Electrical engineering can seem like black magic and witchcraft to car nuts, so it's time to demystify this bold new world of electromobility.

WORDS FRANK MARKUS
ILLUSTRATIONS RYAN LUGO

GETTY IMAGES/ISTOCKPHOTO

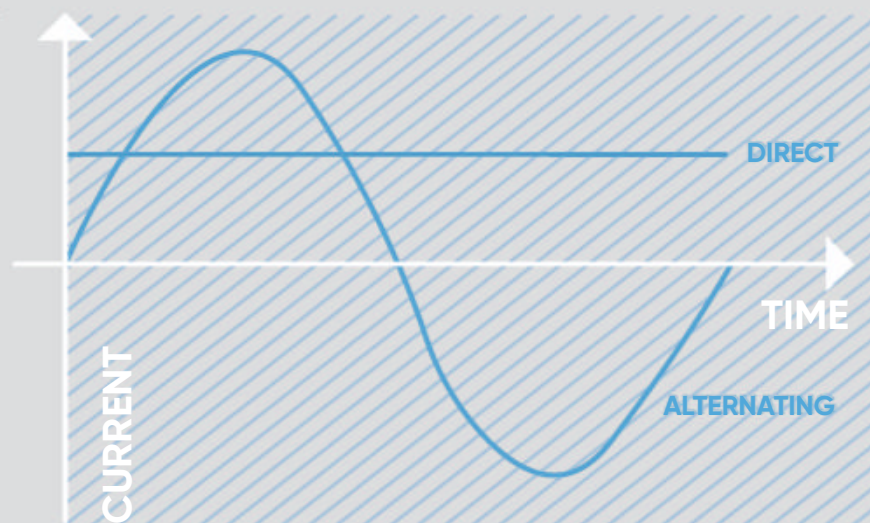


Copper windings form an electromagnetic rotor; direct current is applied via brushes that contact the commutator (black), which switches the electromagnet's polarity every revolution to keep the motor spinning.

How Does an Electric Motor Work?

It has to do with magnetism and the natural interplay between electric fields and magnetic fields. When an electrical circuit closes, allowing electrons to move along a wire, those moving electrons generate an electromagnetic field complete with a north and a south pole. When this happens in the presence of another magnetic field—either from a different batch of speeding electrons or from Wile E. Coyote's giant ACME horseshoe magnet, those opposite poles attract, and like poles repel each other.

Electric motors work by mounting one set of magnets or electromagnets to a shaft and another set to a housing surrounding that shaft. By periodically reversing the polarity (swapping the north and south poles) of one set of electromagnets, the motor leverages these attracting and repelling forces to rotate the shaft, thereby converting electricity into torque and ultimately turning the wheels. Conversely—as in the case of regenerative braking—these magnetic/electromagnetic forces can transform motion back into electricity.



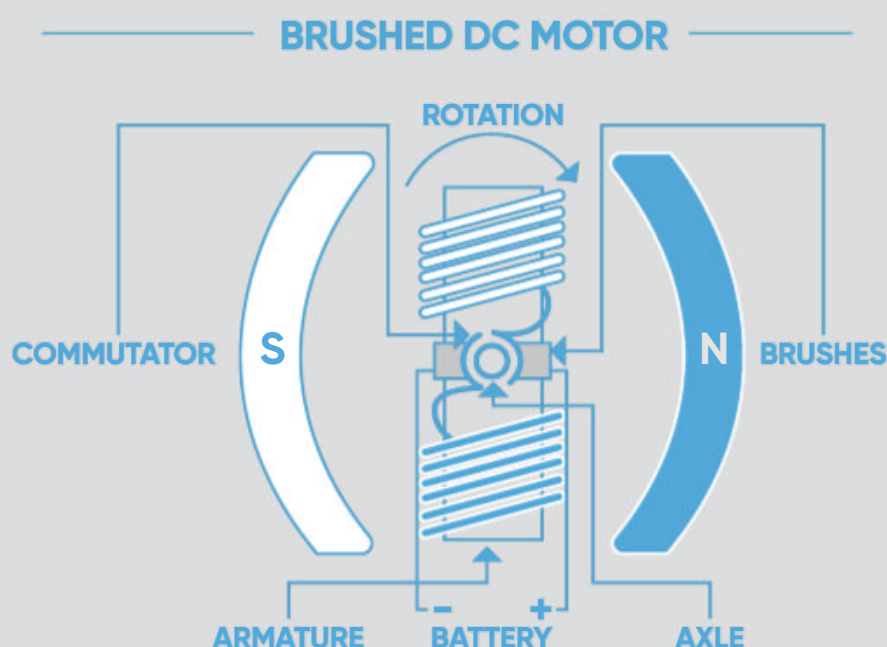
AC or DC?

The electricity supplied to your home arrives as alternating current (AC), so called because the north/south or plus/minus polarity of the power changes (alternates) 60 times per second. (That is, in the U.S. and other countries operating at 110 volts; countries with a 220-volt standard typically use 50-Hz AC.) Direct current (DC) is what goes into and comes out of the + and - poles of every battery. As noted above, a motor requires alternating current to spin. Without it, the electromagnetic force would simply lock the north and south poles together. It's the cycle of continually switching north and south that keeps a motor spinning.

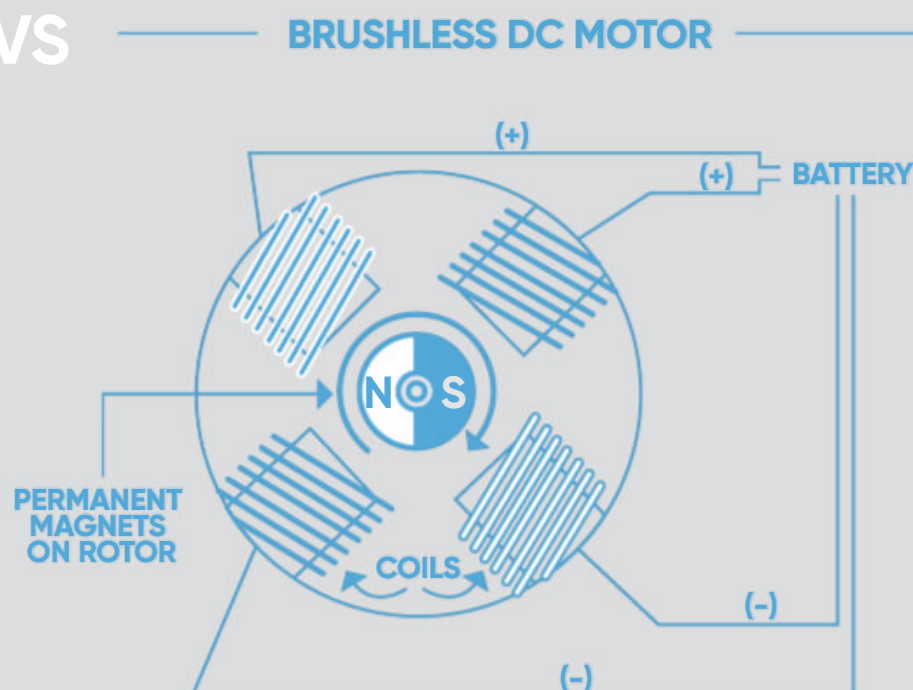
Today's electric cars are designed to manage both AC and DC energy on board. The battery stores and dispenses DC current, but again, the motor needs AC. When recharging the battery, the energy comes into the onboard charger as AC current during Level 1 and Level 2 charging and as DC high-voltage current on Level 3 "fast chargers." Sophisticated power electronics (which we will not attempt to explain here) handle the multiple onboard AC/DC conversions while stepping the voltage up and down from 100 to 800 volts of charging power to battery/motor system voltages of 350–800 volts to the many vehicle lighting, infotainment, and chassis functions that require 12–48-volt DC electricity.

Types of Electric Motors EVs Use

DC Motor (Brushed): Yes, we just said AC makes the motor go around, and these old-style motors that powered early EVs of the 1900s are no different. DC current from the battery is delivered to the rotor windings via spring-loaded "brushes" of carbon or lead that energize spinning contacts connected to wire windings. Every few degrees of rotation, the brushes



VS



HOW ELECTRIC CARS WORK

energize a new set of contacts; this continually reverses the polarity of the electromagnet on the rotor as the motor shaft turns. (This ring of contacts is known as the commutator.)

The housing surrounding the rotor's electromagnetic windings typically features permanent magnets. (A "series DC" or so-called "universal motor" may use an electromagnetic stator.) Advantages are low initial cost, high reliability, and ease of motor control. Varying the voltage regulates the motor's speed, while changing the current controls its torque. Disadvantages include a lower life span and the cost of maintaining the brushes and contacts. This motor is seldom used in transportation today, save for some Indian railway locomotives.

Brushless DC Motor (BLDC) The brushes and their maintenance are eliminated by moving the permanent magnets to the rotor, placing the electromagnets on the stator (housing), and using an external motor controller to alternately switch the various field windings from plus to minus, thereby generating the rotating magnetic field.

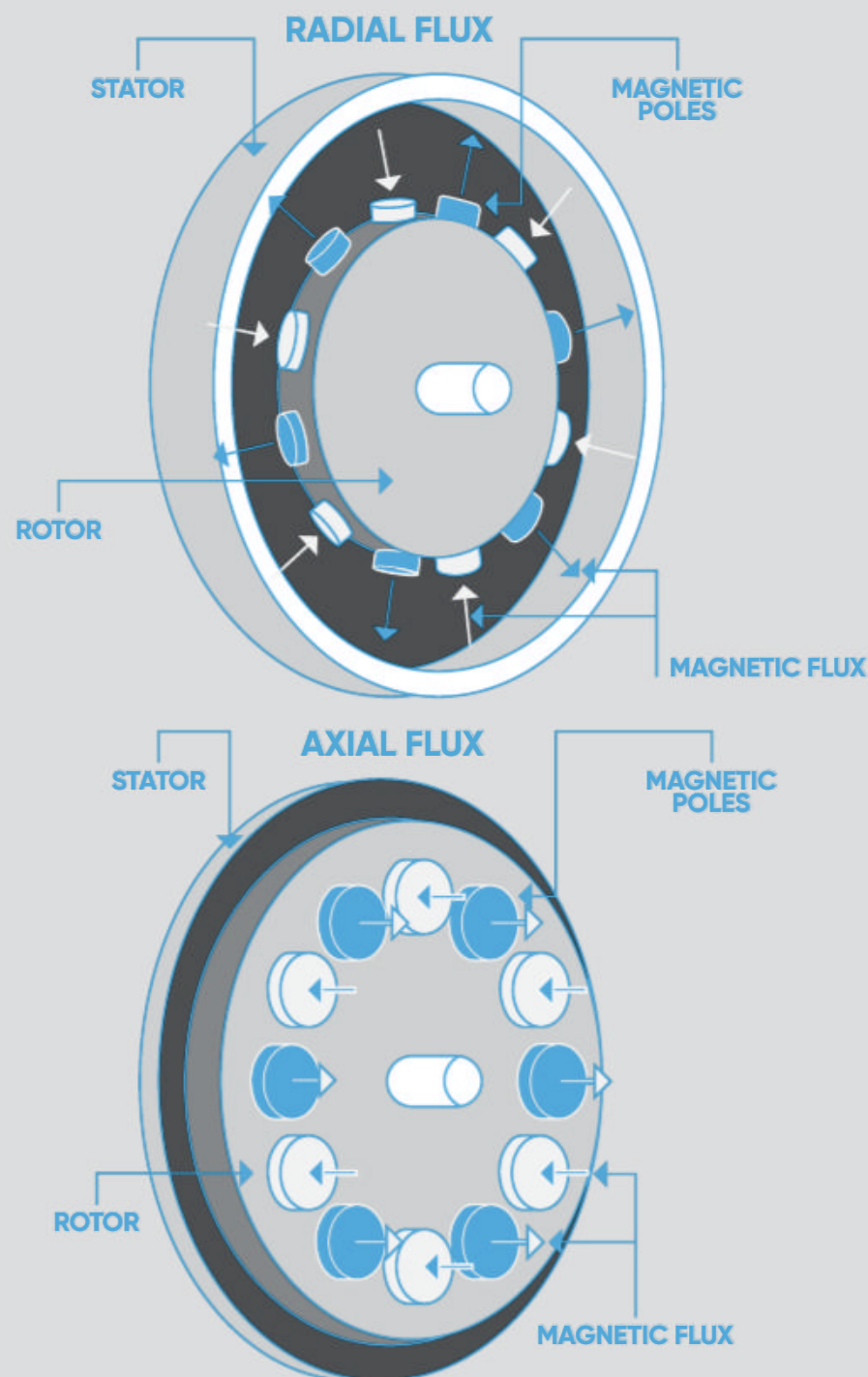
Advantages are long life span, low maintenance, and high efficiency. Disadvantages are higher initial cost and more complicated motor speed controllers that typically require three Hall-effect sensors to get the stator-winding current phased correctly. That switching of the stator windings can result in torque ripple—periodic increases and decreases in the delivered torque. This type of motor is popular for smaller vehicles like electric bikes, and it's used in some ancillary automotive applications like electric power steering assist.

Permanent-Magnet Synchronous Motor (PMSM)

Physically, the BLDC and PMSM motors look nearly identical. Both feature permanent magnets on the rotor and field windings in the stator. The key difference is that instead of using DC current and switching various windings on and off periodically to spin the permanent magnets, the PMSM functions on continuous sinusoidal AC current. This means it suffers no torque ripple and needs only one Hall-effect sensor to determine rotor speed and position, so it's more efficient and quieter.

The word "synchronous" indicates the rotor spins at the same speed as the magnetic field in the windings. Its big advantages are its power density and strong starting torque. A main disadvantage of any motor with spinning permanent magnets is that they create "back electromotive force" when not powered at speed, which causes drag and heat that can demagnetize the motor. This motor type also sees some duty in power steering and brake systems, but it has become the motor design of choice in most of today's battery electric and hybrid vehicles.

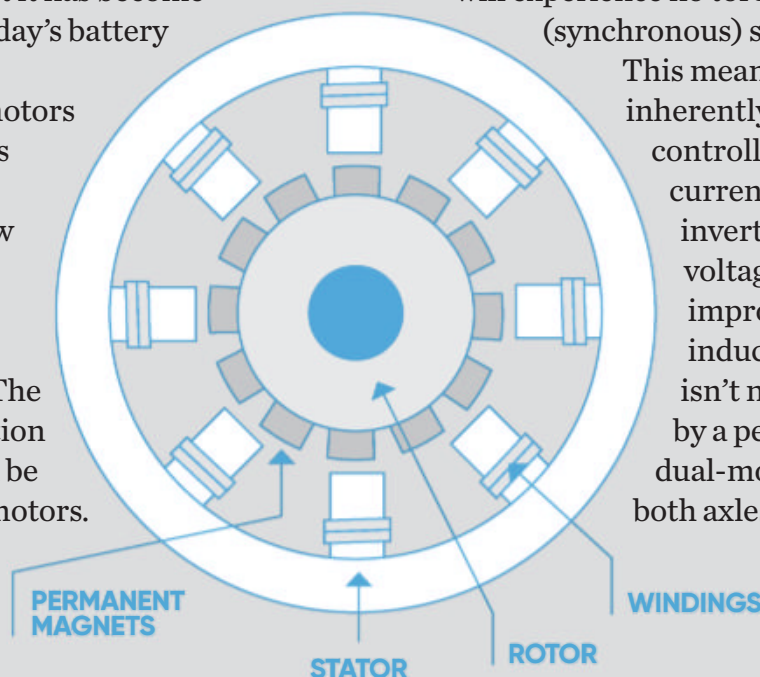
Note that most permanent-magnet motors of all kinds orient their north-south axis perpendicular to the output shaft. This generates "radial (magnetic) flux." A new class of "axial flux" motors orients the magnets' N-S axes parallel to the shaft, usually on pairs of discs sandwiching stationary stator windings in between. The compact, high-torque axial flux orientation of these so-called "pancake motors" can be applied to either BLDC or PMSM type motors.



AC Induction For this motor, we toss out the permanent magnets on the rotor (and their increasingly scarce rare earth materials) and keep the AC current flowing through stator windings as in the PMSM motor above.

Standing in for the magnets is a concept Nikola Tesla patented in 1888: As AC current flows through various windings in the stator, the windings generate a rotating field of magnetic flux. As these magnetic lines pass through perpendicular windings on a rotor, they induce an electric current. This then generates another magnetic force that induces the rotor to turn. Because this force is only induced when the magnetic field lines cross the rotor windings, the rotor will experience no torque or force if it rotates at the same (synchronous) speed as the rotating magnetic field.

This means AC induction motors are inherently asynchronous. Rotor speed is controlled by varying the alternating current's frequency. At light loads, the inverter controlling the motor can reduce voltage to reduce magnetic losses and improve efficiency. Depowering an induction motor during cruising when it isn't needed eliminates the drag created by a permanent-magnet motor, while dual-motor EVs using PMSM motors on both axles must always power all motors.



WHAT IS AVAXHOME?

AVAXHOME-

the biggest Internet portal,
providing you various content:
brand new books, trending movies,
fresh magazines, hot games,
recent software, latest music releases.

Unlimited satisfaction one low price

Cheap constant access to piping hot media

Protect your downloadings from Big brother

Safer, than torrent-trackers

18 years of seamless operation and our users' satisfaction

All languages

Brand new content

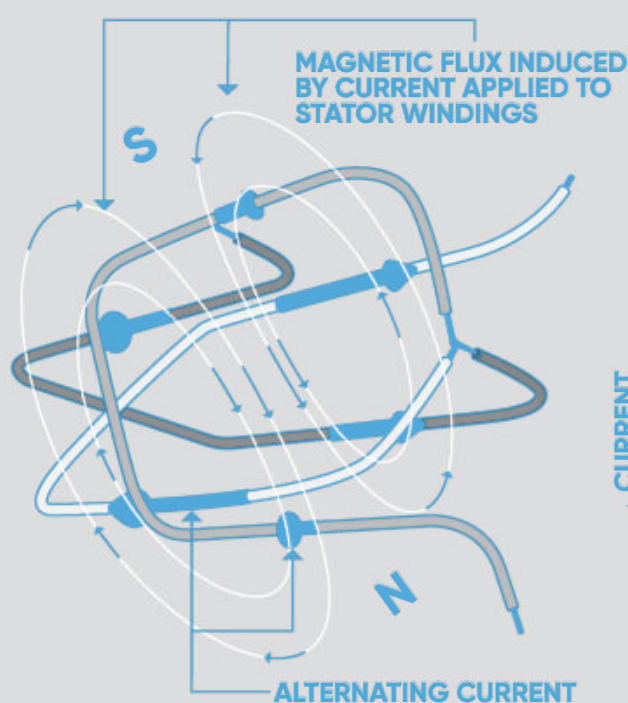
One site



AVXLIVE • ICU

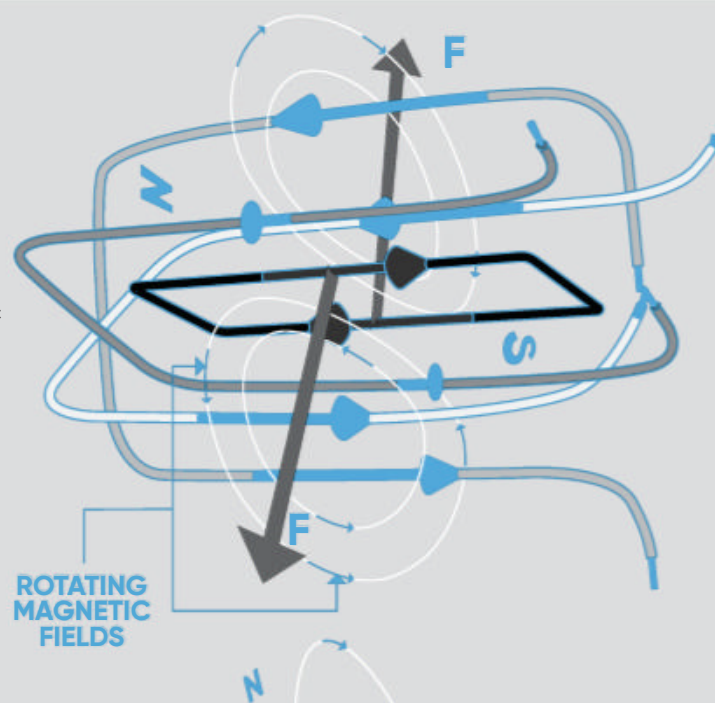
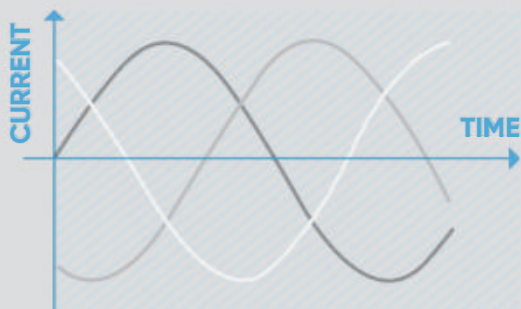
AvaxHome - Your End Place

We have everything for all of your needs. Just open <https://avxlive.icu>



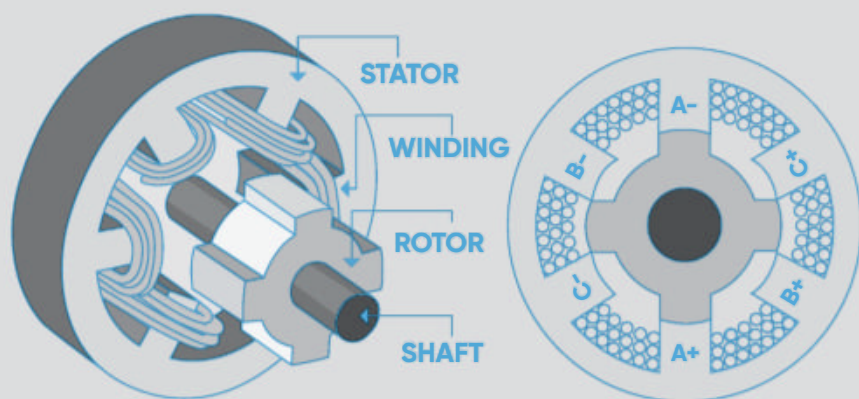
Here the white and light/dark gray wires represent three phases of stator windings. When AC current flows through them (blue arrows), a magnetic field (the ovoid lines marked "N" and "S") begins to rotate.

As those rotating magnetic field lines pass through circular windings on the rotor (right, black), they induce electric flow in this loop (black arrows). This sets up another magnetic force (gray arrows), which creates torque.



Peak efficiency may be slightly greater for BLDC or PMSM designs, but AC induction motors often achieve higher average efficiency. Another small trade-off is slightly lower starting torque than PMSM. The GM EV1 of the mid-1990s and most Teslas have employed AC induction motors.

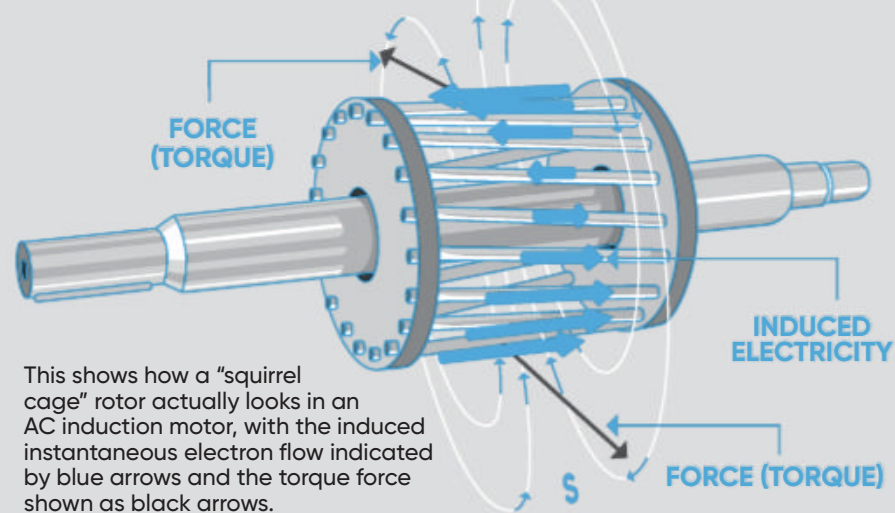
Reluctance Motor Think of “reluctance” as magnetic resistance: the degree to which an object opposes magnetic flux. A reluctance motor’s stator features multiple electromagnet poles—concentrated windings that form highly localized north or south poles. In a switched reluctance motor (SRM), the rotor is made of soft magnetic material like laminated silicon steel, with multiple projections designed to interact with the stator’s poles. The various electromagnet poles are turned on and off in much the same way the field windings in a BLDC motor are. Using an unequal number of stator and rotor poles ensures some poles are aligned (for minimum reluctance) while others are directly in between opposite poles (maximum reluctance). Switching the stator polarity then pulls the rotor around at an asynchronous speed.



A synchronous reluctance motor (SynRM) doesn’t rely on this imbalance in the rotor and stator poles. Rather, SynRM motors feature a more distributed winding fed with a sinusoidal AC current as in a PMSM design, with speed regulated by a variable-frequency drive, and an elaborately shaped rotor with voids shaped like magnetic flux lines to optimize reluctance.

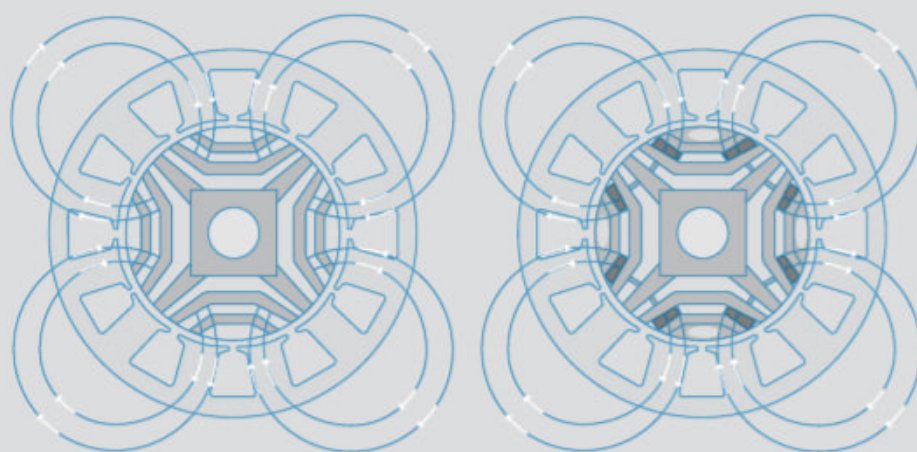
The latest trend is to place small permanent magnets (often simpler ferrite ones) in some of these voids to take advantage of both magnetic and reluctance torque while minimizing cost and the back EMF (or counter-electromotive force) high-speed inefficiencies that permanent-magnet motors suffer.

Advantages include lower cost, simplicity, and high efficiency. Disadvantages can include noise and torque ripple (especially for switched reluctance motors). Toyota introduced an internal permanent-magnet synchronous reluctance motor (IPM SynRM) on the Prius, and Tesla now pairs one such motor with



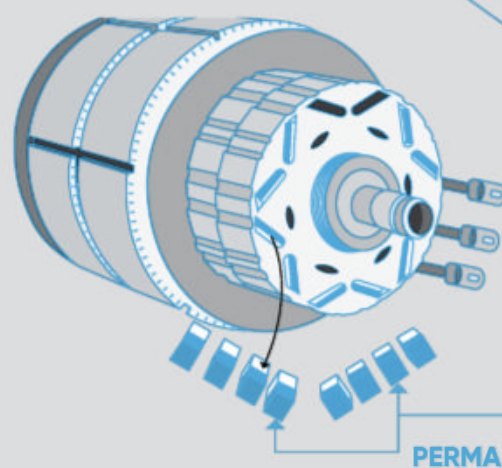
This shows how a “squirrel cage” rotor actually looks in an AC induction motor, with the induced instantaneous electron flow indicated by blue arrows and the torque force shown as black arrows.

SYNCHRONOUS RELUCTANCE MOTORS



PLAIN IRON ROTOR

IRON ROTOR WITH PERMANENT MAGNETS



PERMANENT MAGNETS

The rotors in synchronous reluctance motors frequently feature peculiar voids shaped like magnetic flux lines to optimize the reluctance force of the metal. Small amounts of permanent-magnet material tucked into these voids can improve motor performance while greatly limiting the “back electromagnetic force” that full permanent-magnet motors suffer at higher speeds.

an AC induction motor on its Dual Motor models. Tesla also uses IPM SynRM as the single motor for its rear-drive models.

Electric motors may never sing like a small-block or a flat-plane-crank Ferrari. But maybe, a decade or so from now, we’ll regard the Tesla Plaid powertrain as fondly as we do those engines, and every car lover will be able to describe in intimate detail what kind of motors it uses. ■



ONE VOLVO AND A CHOICE BETWEEN ELECTRICITY OR GAS. HOW DO YOU CHOOSE?



Convenience. It all comes down to convenience. Our society is built around the convenience afforded by the internal combustion engine. Whether moving ourselves or our goods, gasoline and diesel have made everything possible. As has a network of hundreds of thousands of branded gas stations around the globe; miles apart or across the street, they allow us to refuel a vehicle in a matter of minutes.

This is the market reality facing electric vehicles. They're catching up quickly in price, range, and performance, but even the best haven't reached parity yet. When you ask which version of the same car you should buy, the answer is a question: What price will you pay for convenience?

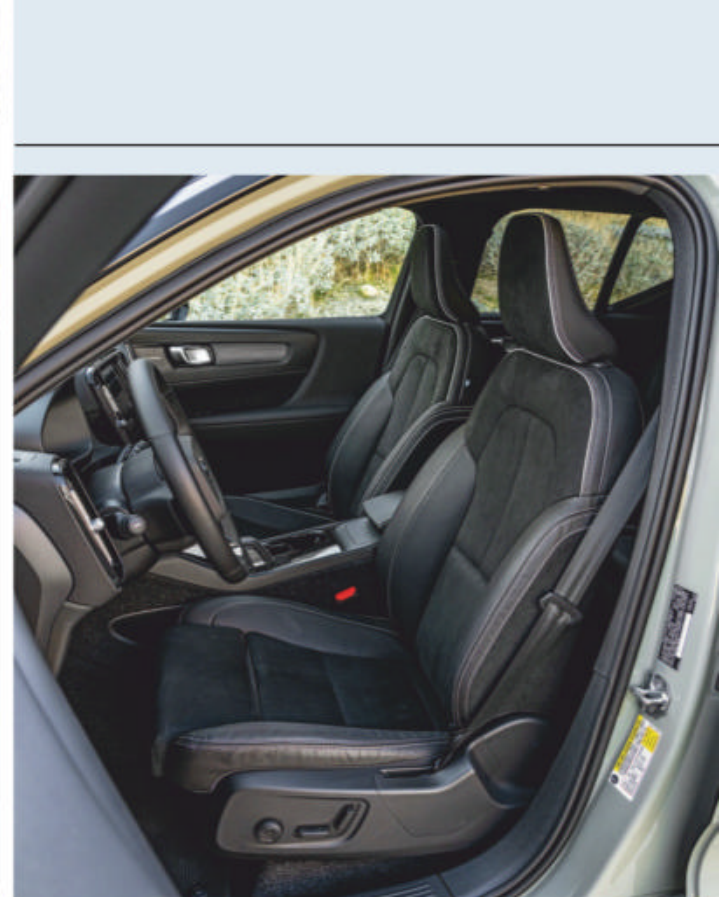
For clarity, it's useful to remove variables by examining a vehicle offering both types of powertrains, in this case the Volvo XC40 and its gas T5 AWD and electric Recharge T8 AWD variants. It also helps to remember where we came from. The automobile arrived before the gas station, just as the electric car came before the electric vehicle charger. Bertha Benz had to convince the local druggist in Wiesloch to mix her up some ligroin (a petroleum-based solvent) to complete the world's first automobile road trip when the ol' Benz Patent Motor Car ran dry. Today, you can buy gas nearly anywhere.

Just as there was a druggist in nearly every village in 1888, there's an electrical outlet in most inhabited places today.

Depending on the supplies the druggist had on hand, it's an even guess which would be a slower fill-up. Today's gas stations can dispense 10 gallons per minute. High-speed electric chargers and the electric cars capable of taking advantage of them are narrowing the gap, but there are fewer than 150,000 of those chargers globally, and they're not at all evenly distributed.

In the U.S. in 2020, for example, there were fewer than 4,000 fast chargers, compared with 168,000 gas stations, each with multiple pumps, per the U.S. Department of Energy and National Highway Traffic Safety Administration, and public charging stations are clustered in major cities and along major travel corridors.





Volvo XC40 P8 AWD Recharge

This won't be the case for long, though. The Biden administration has committed to building more than 500,000 public chargers by 2030. Private companies have pledged to build thousands more in the next few years. Vehicles able to take advantage of high-power charging are hitting the market, and more are promised every day. We've reached an inflection point in the mass adoption of the electric vehicle, the same way a horse-riding nation did with the automobile a century ago.

Where, though, does this leave today's EV buyer? It depends. Right now, most EV buyers are homeowners who can plug in every night and need only visit a public charger on a road trip. Not ever having to visit a gas station is an oft-cited EV advantage, but otherwise, driving one to work or to run errands isn't all that different from driving a gas-powered vehicle. Today, the road trip is the great equalizer.

Consider this comparison test a snapshot, the clearest look at the pros and cons of EV ownership compared to an otherwise identical gas-powered car.

The Basics

To keep things as even as possible, I set some ground rules. Both vehicles would start with a full tank or battery. I would make a 400-mile round trip in both cars on back-to-back weekdays to guarantee



At 81 percent charge, the electric Volvo XC40 has about 165 miles of range left.

Battery level
81%

each would be driven in the same manner and in as similar conditions as possible. I'd start at the same time each day and set the climate control at 72 degrees. I would drive as normally as possible, making no effort to game the results. I would do no advance research on gas station and charger locations. I would just get in the car and drive and figure it out on the way, just like most people do when they road trip in a gas-powered car.

The results speak to the central question: What cost convenience? The trips were remarkably similar. Each required a stop halfway to the turnaround point in Paso Robles, a stop at that point itself, and a stop halfway back. Traffic was effectively the same, as were the average speeds. The differences came in cost, both in terms of time and money, which each advantaged one vehicle over the other.

Dollars and Sense

In monetary terms, charging the Recharge three times on the trip and upon returning home cost between \$66.29 and \$70.20 for 187 kilowatts. Why the range? My home electrical utility charges different rates per kilowatt-hour of electricity depending on whether I exceed certain usage thresholds each month, so the price range reflects the lower and higher amounts I might be charged depending on the month.

Of that, \$51.93 was spent on three public chargers. I used Electrify America chargers, as they were the only option for two

of my three stops and accept credit cards rather than requiring a membership and a special RFID card. They charge \$0.43 per kilowatt-hour. Given that 33.7 kWh equals the energy content of 1.0 gallon of gas, that's like charging \$14.91 per gallon. When there's only one charging station on your route, though, what can you do?

The first stop cost \$14.62 for 35 kWh and took 28 minutes. The second cost \$18.39 for 42.75 kWh and took 33 minutes, partly because I switched chargers in the middle to allow a couple



Although the gas and electric models look nearly identical, driving each from L.A. to California's hottest wine region and back reveals critical differences.

with a Nissan Leaf access to the only plug that fit their car. The third stop cost \$18.92 for 44 kWh and took 31 minutes. Charging at home that night cost between \$14.36 and \$18.27 for 65.25 kWh and took nine hours. Public fast charging is expensive; hopefully that will continue to change with competition. (We did this same comparison with an identical loop a year ago in two Hyundai Konas, and the Kona Electric cost \$140.97 to charge. So although public charging is still no bargain, it's cheaper than it was.)

Filling the gas XC40's tank is a much simpler calculation. Gassing up once on the road and again when I got home to see how much gas I'd used cost \$73.94 for 17.11 gallons of the premium fuel required for the T5's turbo engine. A small price penalty versus the Recharge EV version, but it's worth noting I was able to comparison shop gas prices at different stations to save money, whereas I had virtually no alternative to the EV chargers I used and couldn't go across the street to save a buck.

Measured in time, it goes the other way. The Recharge needed to be charged at the quarter, halfway, and three-quarter points of the journey. The T5 only required us to stop once for gas, on the way home. The entire trip in the Recharge took 9 hours, 11 minutes, compared to 8 hours, 31 minutes in the T5. That's an increase of 7.8 percent, or 10 minutes per 100 miles traveled on electricity.



There are caveats, of course. The T5 only needed one stop for gas, but I also stopped once on the way out to use the restroom and at the turnaround point to eat lunch, so I ended up stopping the same number of times as I had in the Recharge.

Let's Be Real

Now, if you're a road trip camel who can go hours without using a restroom or touching your phone, and if you bring your food and drink with you, you could shave time off the T5's total, and using a vehicle that needs only regular unleaded would save 20 cents or so per gallon.

How much planning and personal discomfort are you willing to invest to get somewhere a little quicker or to save a buck? How much is it worth to have designated times off the road to check your phone safely? What's the value to driving a vehicle that doesn't pollute and that, even when considering materials and construction, creates less pollution in manufacturing? Does the convenience

of stopping at a gas station for a matter of minutes rather than a charger for dozens of minutes outweigh all of that?

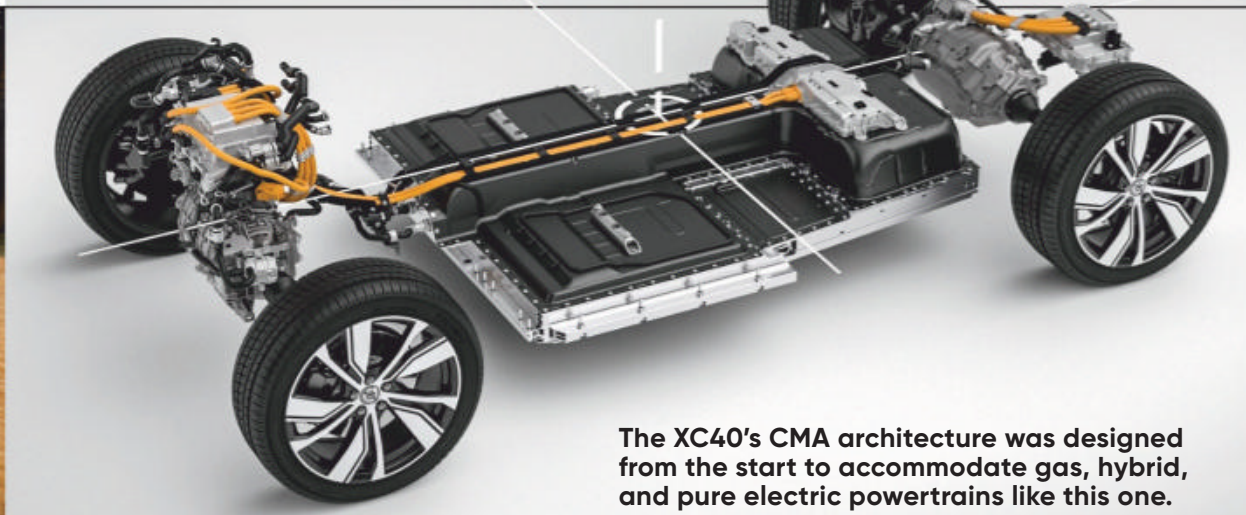
How They Drive

Before you answer, consider the differences in the vehicles themselves. It's not just what powers the wheels; it's what they offer the driver and passengers.

Electric vehicles typically carry their weight lower, which automakers can take advantage of to improve handling. The Recharge EV rides and handles better than the T5, its battery pack's lower mounting point reducing the SUV's center of gravity and imparting a solidity and confidence typically found in German sport sedans. It has a carved-from-granite feeling, ironing out road rash better than the lighter T5 while also feeling more planted and resistant to body roll in corners. The T5 feels noticeably less refined and sporty by comparison, and the T5 is already a nice SUV, all things considered.



COMPARISON



The XC40's CMA architecture was designed from the start to accommodate gas, hybrid, and pure electric powertrains like this one.

ONE-PEDAL DRIVING LETS YOU DRIVE THE RECHARGE WITH EXTREME PRECISION.

Similarly, there's no question about the superior drivetrain. The T5 is reasonably quick getting up to speed on an interstate on-ramp and overtaking slow cars on the open highway, but it can't hold a candle to the Recharge. The EV was quick enough to genuinely surprise our test team, and once you've had a taste of that instantaneous, linear power delivery, it's hard to go back.

Whereas the T5 needs to change down a gear or three and the power comes in surges as the turbocharger spools up, the Recharge takes off like a shot every time. Enabling "one-pedal driving" not only allows you to recoup more battery power but also lets you drive the Recharge with extreme precision, simply by easing off the accelerator pedal.

But how much is the EV's superior driving experience worth to you when weighed against the longer travel time?



The Volvo XC40 Recharge offers front cargo storage, though it's less than in most EVs.

More Practical Matters

EVs have other inherent advantages. With no gasoline engine under the hood, the Recharge has extra cargo space up front. It'll also never require an oil change, and a set of brake pads could last the vehicle's entire life. There's no timing belt or chain to replace, fewer fluids to leak, no emissions test to pass. How much are those conveniences worth compared to getting there sooner?

There are also bonuses specific to this particular EV. The XC40 Recharge gets several upgrades compared to the T5, the most significant being a Google-based infotainment system complete with Google Assistant. A million times better at understanding your questions and commands than any other voice-recognition software in any other car, the Assistant alone might be worth taking the EV leap. Don't like digging through menus? Hate typing into the screen one peck at a time? Just say "Hey Google," and tell Assistant what you want.

Normally, I'd do a bit of research and planning before an EV road trip, but I knew I didn't have to this time because I could just tell Google where I wanted to go and ask it to find me a conveniently located charger along the way. And I could do all of this while driving down the



interstate with Volvo's Pilot Assist system helping me steer and handling throttle and braking. (The T5 had Pilot Assist, too.) And as I'd discover, Google Maps continues to better predict travel times and monitor traffic than automaker systems with the same live traffic-monitoring capability.

In addition, the Recharge has no stop/start button. Put it in gear (with one tap of the selector instead of the T5's two, another minor advantage), and it wakes up and goes. It even sets and releases the parking brake automatically, including when you're stopped on a hill. Both cars have a digital instrument cluster, but the Recharge's shows you more information and is easier to read at a glance. The T5 is fairly quiet inside, but Volvo took additional steps in the Recharge to reduce noise, given its lack of engine sounds. The result is noticeable and appreciated. What are all those little conveniences worth



compared to the convenience of stopping less frequently for fuel in the T5?

The gas T5 does have its advantages, though. For one, the air conditioning is considerably more powerful, likely the result of a less powerful electric compressor used on the Recharge to maximize range. I also felt slightly freer to drive as aggressively as I liked in the T5.

Even having a charger set as my destination in the Recharge and knowing I'd arrive with plenty of battery left, there was always a small voice in the back of my head cautioning against accelerating hard on hills, passing too many cars, or setting the cruise control too high, lest I burn too much electricity (which I ignored for the sake of matching driving aggressiveness for this test). In the T5, there was security in knowing I could find a gas station at nearly every exit on the interstate. How much are colder air and a little peace of mind worth weighed against all of the Recharge's other advantages?

Which Way to Go?

Before I finally answer our grand question, I have to consider the context. This test was performed in California, the national leader in EV charger proliferation. The Recharge EV costs an extra \$14,740 as tested, before tax incentives worth more than half the difference, and before counting fuel and maintenance savings over the vehicle's life span. If I say it's the better car and worth the extra expense after weighing the advantages and inconveniences of each, I say so based on my access to the charging infrastructure.

In that regard, I do say so. I'd rather drive the Recharge every day and deal with the inconvenience of longer travel times on road trips. The driving experience, the features, the never having to visit a gas station, the knowledge I've reduced my contribution to air pollution, they're all worth a bit of my time. And remember, before long, EVs will charge substantially quicker than the Recharge does today.

If you don't have a charger at home or if you live somewhere with fewer public chargers, your calculus will be different. But with thousands of new public chargers installed every year, your calculation will change by the day. Right now, the gas-powered vehicle will get you there sooner with the knowledge you can stop almost anywhere to refuel without any planning whatsoever. That may not be the case soon. Knowing most people keep their cars upward of 10 years, you have to ask: What's convenience worth to you today, and what about tomorrow? ■

 POWERTRAIN/CHASSIS		
	2021 Volvo XC40 P8 AWD Recharge (R-Design)	2021 Volvo XC40 T5 AWD (R-Design)
DRIVETRAIN LAYOUT	Front/rear-motor, AWD	Front-engine, AWD
ENGINE/MOTOR TYPE	AC permanent-magnet electric	Turbocharged I-4, alum block/head
VALVETRAIN	—	DOHC, 4 valves/cyl
DISPLACEMENT	—	120.2 cu in/1,969cc
COMPRESSION RATIO	—	10.8:1
POWER (SAE NET)	402 hp (comb)	248 hp @ 5,500 rpm
TORQUE (SAE NET)	486 lb-ft (comb)	258 lb-ft @ 1,800 rpm
REDLINE	—	6,000 rpm
WEIGHT TO POWER	11.8 lb/hp	15.4 lb/hp
TRANSMISSION	1-speed automatic	8-speed automatic
AXLE/FINAL DRIVE RATIO	8.57:1/8.57:1	3.33:1/2.24:1
SUSPENSION, FRONT; REAR	Struts, coil springs, anti-roll bar; multilink, coil springs, anti-roll bar	Struts, coil springs, anti-roll bar; multilink, coil springs, anti-roll bar
STEERING RATIO	15.8:1	15.8:1
TURNS LOCK TO LOCK	2.7	2.7
BRAKES, F; R	13.6-in vented disc; 13.4-in vented disc, ABS	12.7-in vented disc; 11.9-in vented disc, ABS
WHEELS	8.0 x 20-in cast aluminum	7.5 x 19-in cast aluminum
TIRES, F; R	235/45R20 100H; 255/40R20 101H Pirelli P Zero Scorpion VOL EleGT (M+S)	235/50R19 99H Michelin Primacy MXM4 (M+S)
DIMENSIONS		
WHEELBASE	106.4 in	106.4 in
TRACK, F/R	63.0/63.4 in	63.0/63.6 in
L X W X H	174.2 x 73.3 x 65.0 in	174.2 x 73.3 x 65.3 in
GROUND CLEARANCE	6.9 in	8.3 in
APPROACH/DEPART ANGLE	20.0/26.6 deg	21.7/30.4 deg
TURNING CIRCLE	37.4 ft	37.4 ft
CURB WEIGHT (F/R DIST)	4,760 lb (52/48%)	3,807 lb (58/42%)
TOWING CAPACITY	2,000 lb	3,500 lb
SEATING CAPACITY	5	5
HEADROOM, F/R	37.6/38.3 in	37.6/38.3 in
LEGROOM, F/R	40.9/36.1 in	40.9/36.1 in
SHOULDER ROOM, F/R	56.7/56.3 in	56.7/56.3 in
CARGO VOLUME BEH F/R	57.5/21.7 cu ft	57.5/21.7 cu ft
TEST DATA		
ACCELERATION TO MPH		
0-30	1.8 sec	2.0 sec
0-40	2.4	3.2
0-50	3.2	4.5
0-60	4.2	6.2
0-70	5.4	8.2
0-80	6.9	10.6
0-90	8.7	13.7
0-100	10.8	—
PASSING, 45-65 MPH	1.9	3.3
QUARTER MILE	12.8 sec @ 107.7 mph	14.7 sec @ 93.0 mph
BRAKING, 60-0 MPH	118 ft	111 ft
LATERAL ACCELERATION	0.84 g (avg)	0.86 g (avg)
MT FIGURE EIGHT	26.3 sec @ 0.70 g (avg)	27.4 sec @ 0.62 g (avg)
TOP-GEAR REVS @ 60 MPH	6,350 rpm	1,650 rpm
CONSUMER INFO		
BASE PRICE/AS TESTED	\$55,085/\$59,780	\$42,045/\$45,040
AIRBAGS	7: Dual front, front side, f/r curtain, driver knee	7: Dual front, front side, f/r curtain, driver knee
BASIC WARRANTY	4 years/50,000 miles	4 years/50,000 miles
POWERTRAIN WARRANTY	4 years/50,000 miles	4 years/50,000 miles
ROADSIDE ASSISTANCE	4 years/Unlimited miles	4 years/Unlimited miles
FUEL CAPACITY	78 kWh (Li-Ion battery, 75 kWh usable)	14.2 gal
EPA CITY/HWY/COMB ECON	85/72/79 mpg-e	22/30/25 mpg
EPA EST RANGE	208 miles	355 miles
ENERGY CONS, CITY/HWY	40/47 kWh/100 miles	153/112 kWh/100 miles
CO2 EMISSIONS, COMB	0.00 lb/mile (at vehicle)	0.78 lb/mile
RECOMMENDED FUEL	240-volt electricity	Unleaded premium

RIGHT HERE,

VW'S ALL-ELECTRIC ID4 CROSSOVER BATTLES HONDA'S CR-V HYBRID TO THE WIRE



WORDS AARON GOLD
PHOTOGRAPHY DARREN MARTIN

Our choice of vehicles for this SUV comparison test is bound to raise eyebrows. Shouldn't we compare the new battery-powered 2021 Volkswagen ID4 with another electric car? That's how our industry has been doing things, but the time is rapidly approaching when Jane and John Consumer will routinely consider an EV to be simply another option on the list.. It's time to start treating electric vehicles like mainstream cars, so let's compare the ID4 with one of the best eco-friendly crossovers on the market, the 2021 Honda CR-V Hybrid.

Why the Honda? Well, the ID4 is nearly identical to the CR-V Hybrid in dimensions, performance, and—for the moment, at least—price. The limited-run ID4 1st Edition trim tested here bundles a top-of-the-line Pro S version with unique trim

and a pile of otherwise optional aesthetic and comfort features at a slight discount. Factor in the \$7,500 federal tax credit, and our example prices out to \$37,960—just \$40 more than the CR-V Hybrid Touring with optional Platinum White Pearl paint.

Besides, the ID4 might not compare well against some of the flashier EVs on the market because it doesn't have the spleen-flattening acceleration, bladder-busting range, or reimagined interior of a dual-motor Tesla. (That stuff

is coming.) Yes, the ID4 is futuristic, but it's not just an expensive toy for well-heeled techno-mavens. The ID4 is meant to be a daily-drivable, eco-friendly utility vehicle, just like the CR-V Hybrid.

Electric VW vs. Electrified Honda

Only 2 percent of Americans drive electric cars, so we're going to ask the remaining 98 percent to take a couple of things as read. First, let's pretend range anxiety doesn't exist. The ID4's 250-mile range (its EPA-rated figure and, based on our experience, a reliable real-world number) is barely half of what the Honda can do, but remember EV owners can plug in at night and have a full "tank" every morning. Long-distance travel in an electric car is now a possibility, if an inconvenient one.

Once you get over that one basic difference—plug versus pump—the ID4 and



RIGHT NOW

2021 VW ID4 vs. | **COMPARISON**
2021 Honda CR-V Hybrid



CR-V start to overlap in more ways than you might imagine. And picking the best between them proved difficult. Executive summary: The Honda is a bit more utilitarian and practical, and the Volkswagen is a bit more futuristic and fun.

Styling, Outside and In

Kudos to Volkswagen for designing its vehicle of the future accordingly. The ID4's clean styling, with its flush door handles and low stance, makes the CR-V look downright dowdy. Inside, the ID4 doubles down on its car-of-the-future

vibe. In place of the staid and sensible gauges VW has used for years, the ID4 has a small pod atop its steering column that houses a minimalist instrument panel, with speed, range, adaptive cruise status, and next-turn directions displayed on a small screen. Attached to it like Van Gogh's remaining ear is the shifter: Twist for drive or reverse, press the button for park. At center-dash is the infotainment and climate screen. There's a small button on the steering column marked "Engine Start" (old habits die hard), but in normal operation you'll never use it; with the key fob on your person, you unlock the ID4 by squeezing the door handle and "start" it by getting in and stepping on the brake. Putting the car in park and getting out shuts it off.

By comparison, the CR-V's interior seems almost quaint, its faux wood trim

a throwback to the 2020s. The Honda's digital instrument cluster looks massive compared to the VW's. Not that we disliked it; after the VW's sci-fi interior, it was nice to get back to the period-piece Honda and find all the controls more or less where we expect them. Aside from its perennially annoying touchscreen stereo, the CR-V is as user-friendly as can be.

Powertrains Compared

The driving experience is remarkably similar. EVs feel very different to drive than internal combustion vehicles, and the CR-V Hybrid seems more the former, outside of its engine noise. Honda's EarthDreams hybrid system uses an engine to generate electricity (with a small battery buffer) and a motor to drive the wheels. The engine seamlessly connects to drive the wheels directly under certain





Honda CR-V



VW ID4

steady-state or light acceleration conditions exceeding 40 mph. This all means the CR-V Hybrid delivers the same smooth, linear, shift-free acceleration as the ID4.

Regenerative braking provides another interesting similarity. The Honda uses steering wheel paddles to select up to four levels of regen, making it easy to control your speed (and juice up the battery) on long downhill drives. Beyond default operation, the ID4 has a single “B” mode that proved to be just right, slowing the car significantly but never jarringly. In fact, it required barely any conscious adaptation on our part.

You won’t feel the Honda’s engine, but you’ll sure as hell hear it. The engine either drones or moans during regular driving, and if you should ask the CR-V Hybrid to do anything extraordinarily challenging—like, say, drive up a hill—the 2.0-liter sounds as if it’s being tortured. A fast run through curvy roads had us clamoring for the ID4’s relative silence. We say “relative” because the ID4, like the Honda, suffers from plenty of wind noise at highway speeds. Stranger still is how much the ID4 driver hears from surrounding cars, ambient noise the Honda’s shouty engine drowns out.

Neither car is particularly quick. The ID4 we drove features a single 201-hp motor mounted to the rear axle, and our test team clocked it to 60 mph in 7.4 seconds, a perfectly fine performance for

an everyday SUV. Despite having slightly more power and 939 fewer pounds to haul around, the CR-V trailed the Volkswagen to 60 by 0.1 second. EVs often feel like they run out of steam at higher speeds, but in this case it was the CR-V that struggled with top-end acceleration. Passing on a two-laner feels dicier in the CR-V than in the ID4.

Still, both powertrains delivered on their promises: If we kept to the speed limits at all times, the ID4 would exceed its 250-mile range, and the CR-V would come respectably close to its 38-mpg EPA combined rating.

How They Drive

Both ride relatively comfortably, but they bounce around a bit on bumpy roads. The CR-V has a not entirely unpleasant pogo-stick quality, while the ID4 jiggles its passengers at an accelerated frequency, which we assume is a result of stiff shocks trying to control the inertia of the heavy battery pack under the car’s floor.

That heavy battery proved to be both boon and bane on our twisty test route. The ID4 feels like the sports car of this duo, with strong grip and magnificent stability thanks to its low center of gravity. But with weight comes inertia, and one nasty midcorner bump sent the ID4 into oscillations its dampers had trouble reining in. The Honda sailed through the same corner with far less drama.



We had hoped that the ID4’s rear-drive layout would allow for a little tail-out action (because isn’t that what every family wants from their crossover?), and although we could feel the chassis trying to rotate, the stability control wouldn’t let it—and there’s no way to shut the system off. Still, on broad, fast curves, the ID4 feels steady and confident, just what we expect from a German car.

With notably lower levels of power and grip, the CR-V Hybrid struggled (and ultimately failed) to close the gap between itself and the rapidly disappearing Volkswagen. Although body lean is well controlled, there is quite a bit of vertical body travel, which makes for some rather interesting moments when one side of the road rises and the other falls. Our knuckles may have been a bit paler than usual on some of the trickier bits of road.

That said, despite its bouncy ride and limited grip, the Honda displays an underlying competence. Some CUVs cover their eyes and surrender to understeer when driven too fast, but the CR-V Hybrid tries its hardest with the limited resources it has. Driving it fast was its own perverse sort of pleasure, the kind of rule-breaking satisfaction one gets when cutting class or sneaking into a second movie.

Let’s Talk Practicality

We’ll assume most sport utility buyers care more about utility than sport, and here is where the Honda has an edge. Passenger





ingress is marginally easier; the VW is lower to the ground, but that big 77-kWh battery pack raises the floor to a similar height as the CR-V's. Both back seats are comfortable, but the Honda feels a little more spacious, with 2.8 inches more legroom plus toe space under the front seats that the ID4 lacks. But for those who get claustrophobic, the ID4's panoramic glass roof provides more relief than the Honda's small single-pane sunroof.

The CR-V's cargo bay at first glance looks like an airplane hangar compared to the ID4's, but break out the tape measure (which you do all the time, right?), and you'll find the ID4's cargo opening is about the same height and slightly wider. The ID4 conceals some of its cargo space under a removable false floor, which provides a flat surface when the seats are folded down, but the VW's rakish roof is the real problem—the CR-V's closer-to-vertical tailgate provides more space. The Honda's load floor is lower, as well, and we like the pulls that let you drop the rear seat backs from inside the cargo bay.

We must talk about stereos. The VW's infotainment system is designed to work like a tablet, and although it can be confusing at first, it's fairly straightforward to use once you understand its logic. The touchscreen also handles climate controls, adding a layer of complication over the CR-V, but the Honda's audio



POWERTRAIN/CHASSIS	2021 Honda CR-V Hybrid Touring AWD	2021 Volkswagen ID4 1st Edition
DRIVETRAIN LAYOUT	Front-engine, AWD	Rear-motor, RWD
ENGINE TYPE	I-4, alum block/head, plus AC permanent-magnet electric motor	AC permanent-magnet electric motor
VALVETRAIN	DOHC, 4 valves/cyl	N/A
DISPLACEMENT	121.6 cu in/1,993cc	N/A
COMPRESSION RATIO	13.5:1	N/A
POWER (SAE NET)	143 hp @ 6,200 rpm (gas)/181 hp (elec)/212 hp (comb)	201 hp
TORQUE (SAE NET)	129 lb-ft @ 3,500 rpm (gas)/232 lb-ft (elec)	229 lb-ft
REDLINE	Not indicated	Not indicated
WEIGHT TO POWER	17.5 lb/hp	23.2 lb/hp
TRANSMISSION	1-speed automatic	1-speed automatic
AXLE/FINAL DRIVE RATIO	3.89:1/9.55:1 (elec), 3.13:1 (gas, 40-45 mph+)	4.39:1/12.99:1
SUSPENSION, FRONT; REAR	Struts, coil springs, anti-roll bar; multilink, coil springs, anti-roll bar	Struts, coil springs, anti-roll bar; multilink, coil springs, anti-roll bar
STEERING RATIO	12.3:1	15.9:1
TURNS LOCK TO LOCK	2.3	3.3
BRAKES, F; R	12.6-in vented disc; 12.2-in disc, ABS	13.4-in vented disc; 11.0-in drum, ABS
WHEELS	7.5 x 19-in cast aluminum	8.0 x 20-in; 9.0 x 20-in, cast aluminum
TIRES	235/55R19 101H (M+S) Continental CrossContact LX Sport	235/50R20 104T; 255/45R20 105T Bridgestone Alenza Sport A/S (M+S)
DIMENSIONS		
WHEELBASE	104.7 in	108.9 in
TRACK, F/R	62.9/63.5 in	62.5/61.6 in
LENGTH X WIDTH X HEIGHT	182.1 x 73.0 x 66.5 in	180.5 x 72.9 x 64.4 in
GROUND CLEARANCE	8.2 in	7.2 in (mfr est)
APPROACH/DEPART ANGLE	18.9/26.0 deg	17.5/21.2 deg
TURNING CIRCLE	37.4 ft	33.6 ft
CURB WEIGHT	3,720 lb	4,659 lb
WEIGHT DIST, F/R	58/42%	47/53%
TOWING CAPACITY	Not recommended	2,200 lb
SEATING CAPACITY	5	5
HEADROOM, F/R	38.0/39.1 in	41.1/38.4 in
LEGROOM, F/R	41.3/40.4 in	41.4/37.6 in
SHOULDER ROOM, F/R	57.9/55.6 in	57.5/55.9 in
CARGO VOLUME BEH F/R	68.7/33.2 cu ft	64.2/30.3 cu ft
TEST DATA		
ACCELERATION TO MPH		
0-30	2.9 sec	2.6 sec
0-40	4.1	3.8
0-50	5.6	5.4
0-60	7.5	7.4
0-70	10.0	10.0
0-80	13.4	13.3
PASSING, 45-65 MPH	3.9	4.0
QUARTER MILE	16.0 sec @ 86.3 mph	15.9 sec @ 86.3 mph
BRAKING, 60-0 MPH	115 ft	119 ft
LATERAL ACCELERATION	0.81 g (avg)	0.83 g (avg)
MT FIGURE EIGHT	28.0 sec @ 0.60 g (avg)	27.4 sec @ 0.61 g (avg)
CONSUMER INFO		
BASE PRICE	\$37,525	\$45,190*
PRICE AS TESTED	\$37,920	\$45,190*
AIRBAGS	6: Dual front, front side, f/r curtain	6: Dual front, front side, f/r curtain
BASIC WARRANTY	3 years/36,000 miles	4 years/50,000 miles
POWERTRAIN WARRANTY	5 years/60,000 miles	4 years/50,000 miles
BATTERY WARRANTY	8 years/100,000 miles (includes hybrid system)	8 years/100,000 miles
ROADSIDE ASSISTANCE	3 years/36,000 miles	3 years/36,000 miles
FUEL CAPACITY	14.0 gal + 1.4 kWh	77 kWh
EPA CITY/HWY/COMB ECON	40/35/38 mpg	104/89/97 mpg-e
EPA EST RANGE	532 miles	250 miles
ENERGY CONS, CITY/HWY	84/96 kWh/100 miles	32/38 kWh/100 miles
CO2 EMISSIONS, COMB	0.52 lb/mile	0.00 lb/mile (at vehicle)
RECOMMENDED FUEL	Unleaded regular	240-volt electricity

*Before applicable federal and local tax credits.



There's also a "regular" new '22 Bolt. Aim your phone here to read the details.

Chevy's Model Why?

When the Chevrolet Bolt EV's SUV sibling broke cover, we wondered: Why'd Chevy make the two Bolts look so similar? How will salespeople steer buyers into the Bolt EUV over a cheaper gas SUV? Why does the longer EUV have less cargo space than the EV? And what's it like to drive?

We'll tackle that last one first. The EUV's extra 90 pounds and 6.3 inches of length relative to the junior Bolt go unnoticed from the driver's seat. Floor it, and the two front tires still struggle for grip—especially when turning—and it always feels even zippier than its mid-6-second 0–60 time suggests.

In its one-pedal driving mode, lifting off the accelerator provides ample deceleration for most driving conditions. A paddle on the left side of the steering wheel provides on-demand energy regeneration while also increasing the deceleration rate in Normal and one-pedal modes. The steering still feels rheostatic, but the simple strut front/torsion-beam rear suspension reacts predictably and with reasonable verve. Ride quality seems class competitive: firm, supple, never overly jarring.

EPA range isn't finalized, but Chevy predicts 250 miles. Buy or lease an EUV, and Chevy will install a 240-volt NEMA 14-50 outlet for you, enabling a full charge in seven hours.

The Bolt EUV's killer app may be its Super Cruise hands-free adaptive cruise control, which comes standard on the \$43,495 Launch Edition and adds \$2,200 to the price of the \$38,495 Premier. That makes a Bolt EUV with Super Cruise \$8,495 to \$17,775 cheaper than the least expensive vehicles with equivalent systems from Tesla and Cadillac. The Bolt EUV is the first non-Cadillac to get Super Cruise, but Chevy's version doesn't support hands-free lane changes as in the latest Cadillacs. Even so, for anyone with a long daily freeway commute, this might represent the biggest vehicular quality of life increase \$40,695 can buy. Can't swing Super Cruise? Basic adaptive cruise control is now available.

Regarding the looks, Bolt EV buyers are among Chevy's most loyal and satisfied, so the brand was keen to retain them with an option offering more interior space. Stretching the Bolt EV's wheelbase by 2.9 inches added 3.1 inches of rear legroom, making it roughly as comfortable for four passengers as a Ford Mustang Mach-E or Tesla Model Y, and legroomier than the new Volvo XC40 Recharge and VW ID4. Because it's 3 to 6 inches narrower than those vehicles, a third rear rider will feel smooshed, but the other two will enjoy remarkable thigh support, a pull-down center armrest, laudable seat cushion and backrest comfort, and reasonable space.

Using the Chevy lineup as a lens, the Bolt EUV's compact powertrain gives it Trailblazer interior room in a body smaller than the Trax's. Because its price aligns better with the fancier Blazer's, the interior has been spiffed up with available yellow contrast stitching and white piping, triangle-shaped perforations on the seat and dash inserts, soft-touch stitched material on the dash and doors, ambient lighting, and a 10.2-inch center infotainment screen.

As for cargo space, because SAE measurements in the EUV are in part dictated by the height of the hatch hinges, max capacity ends up slightly smaller than in the regular Bolt EV—56.9 versus 57.0 cubic feet. In reality, you'll fit about two more cubes of stuff in an EUV. Both figures eclipse the SAE numbers for the Tesla Model Y (54.4 cubic feet) and approach those of the XC40 Recharge (57.5) and Mach-E (59.7).

There's little arguing that the Bolt EUV delivers good range and a lot of automotive tech even at its base MSRP of \$33,995, and that's before factoring in the availability of Super Cruise. For EV intenders willing to ask themselves one more question—"What's out there beyond the Teslasphere?"—this Chevy just might be the answer. **Frank Markus**

and navigation systems still frustrate us. It takes several button presses to move between common functions, and the voice recognition system strikes us as both patronizing and deliberately obtuse. Sound quality from the Honda's stereo is better, though, particularly at higher volumes.

The Winner, but Only by a Smidge

The object of our comparison tests is to pick a definitive winner, and here we struggle, not because the Volkswagen ID4 and Honda CR-V Hybrid are so different but because they are so similar. We were surprised to learn these two SUVs have much in common, good and bad.

The ID4 looks better and is more fun to drive, but its rear-drive layout is a potential detriment to those who live where it rains and snows. That fact, plus the CR-V's roomier back seat and upright cargo bay—and the fact that it delivers all-wheel drive for the price of the RWD VW—makes the Honda the winner in this comparison test, by the narrowest of margins. VW was able to create an electric SUV nearly as good as, and in many ways better than, one of the best gasoline-fueled SUVs on the market, which is an impressive feat. The ID4 has what it takes to go toe to toe with conventional SUVs, right out of the gate. ■

Volkswagen ID4 Pros:

- Futuristic, functional cabin
- Everyday practicality
- Dynamics we expect from VW

Volkswagen ID4 Cons:

- Busy ride on rough roads
- Rear drive only (AWD coming soon)
- Steep infotainment learning curve

Honda CR-V Pros:

- Remarkable fuel economy for an SUV
- Generous passenger/cargo space
- Enjoyable to drive quickly

Honda CR-V Cons:

- Noisy engine
- Apathetic acceleration
- Cumbersome infotainment system



2022 Chevrolet Bolt EUV	
PRICE	\$33,995–\$43,495
LAYOUT	Front-motor, FWD, 5-pass, 4-door SUV
MOTOR	200-hp/266-lb-ft AC permanent-magnet electric
TRANSMISSION	1-speed auto
CURB WEIGHT	3,700 lb (mfr)
WHEELBASE	105.3 in
L X W X H	169.5 x 69.7 x 63.6 in
0-60 MPH	6.5 sec (MT est)
EPA FUEL ECONOMY	Not yet rated (estimated EPA range: 250 mi)
ON SALE	Summer 2021



DAX SHEPARD

ROB CORDDRY

JETHRO BOVINGDON

MOTORTREND Presents

Top Gear AMERICA



JOIN US FOR THE
JOYRIDE

TO START YOUR FREE TRIAL GO TO:
[MOTORTREND.COM/TOPGEARAMERICA](https://www.motortrend.com/topgearamerica)

STREAM EVERY
EPISODE NOW



The dawn of the jet age, the point at which turbine-driven flight had become unquestionably the way forward, came just as piston-powered planes reached their peak. This meeting of eras led aircraft engineers to ease the transition with hybrid, mixed-format designs such as the Navy's FR-1 Fireball and the Air Force's B-36 Peacemaker, the latter of which had six 28-cylinder engines and four turbojet engines. We sit at a similar inflection point in the automotive industry today, when modern plug-in hybrid cars and SUVs like the 2021 Mitsubishi Outlander PHEV and 2021 Toyota RAV4 Prime stand as analogues for those hybrid aircraft, bridging the purely internal combustion powertrains of the past and the electric propulsion of the future.

Those early hybrid airplanes leaned on their piston engines for efficiency and instantaneous acceleration, and their jets provided speed. The latest plug-in hybrids sport electric motors for instant thrust and efficiency while their gas engines provide for long-distance cruising. In other words, whether in a plane or a car, a hybrid system aims to provide the best of all worlds.

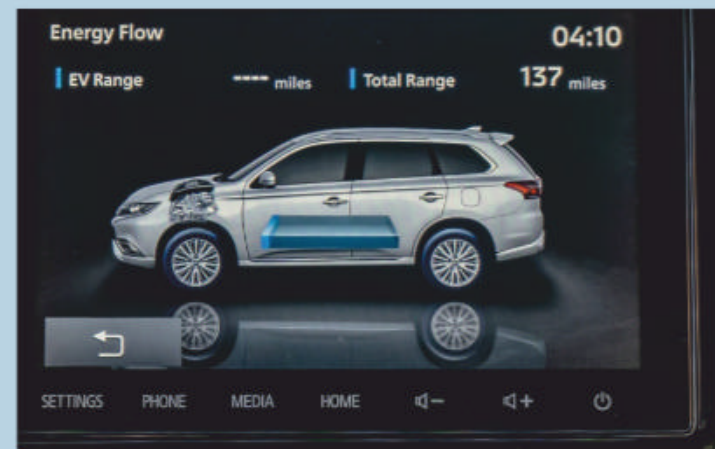
The Mitsubishi Outlander PHEV (represented here by a top-spec GT model) and the Toyota RAV4 Prime (a loaded

XSE) are in many ways the most relevant of the roughly 30 plug-in hybrids on the market today. Why? Simple: They're SUVs, that most popular of body styles. Our pair is in an exclusive class; they and the Ford Escape PHEV, Jeep Wrangler 4xe, and Subaru Crosstrek Hybrid compose the mainstream PHEV SUV roster. But because they're SUVs, people might actually want to buy them, unlike loathsome Toyota Prius Primes or Ford Fusion Energis—ew, hatchbacks and sedans! It might also help explain why the Outlander PHEV is the best-selling plug-in hybrid in the world, even if its maker's American presence is essentially nil.

The Outlander PHEV may be the world's best-selling pluggable hybrid, but is it actually the best such SUV on the market? With the RAV4 Prime—a hybridized version of America's top-selling SUV—and Outlander PHEV in hand, we set out to determine which reigns supreme.

What's a Plug-In Hybrid, and Why Would I Want One?

First, let's talk briefly about what plug-in hybrids are and how they work. A "normal" hybrid (think Prius) has a gasoline engine, at least one electric motor, and a small battery pack. These traditional hybrids use their gas engines



and regenerative braking to charge the batteries, allowing one or more electric motors to assist acceleration and (very) occasionally provide propulsion sans engine. This results in improved fuel efficiency and lower emissions. Like any other fossil fuel-powered vehicle, "plugging in" here means jamming a nozzle into its fuel filler at a service station.

A plug-in hybrid builds on that formula, however, with a much larger battery pack (the RAV4 Prime, for example, has an 18.1-kWh battery, while the RAV4 Hybrid has a 1.6-kWh battery) and, often, more powerful electric motors. Its battery can be charged by plugging the included charging cable into a normal 120-volt (or 240-volt) household wall outlet or by using a public charging station, and its engine can be fueled at a normal filling station. With a

BRIDGING THE

THESE TWO PLUG-IN HYBRID SUVs AIM TO TRANSPORT YOU FROM YOUR LAST CONVENTIONAL CAR TO YOUR FIRST EV



fully charged battery, the best modern plug-in hybrids function like an electric car, driving solely on electric power, with the engine only turning on in certain circumstances, such as under heavy accelerator applications or above certain road speeds. Once the battery is depleted and you're out of electric range, the engine fires up, and you continue on your merry way, with the vehicle operating like a traditional hybrid.

So why choose a plug-in hybrid over a traditional one? Provided you have a place to plug in at home or work—or even while running normal errands—to keep the batteries somewhere near topped up, a plug-in hybrid is vastly easier on fuel and cheaper overall to run, and it provides you with most of the benefits of EV ownership without drawbacks like range anxiety or concerns about charging times or networks. You don't even have to plug in your plug-in hybrid, though neglecting to do so will likely result in fewer miles per gallon than if you had opted for a regular hybrid.

Cost is the other benefit of a plug-in hybrid. There's no denying it: Neither the \$43,190 base MSRP for the Outlander tested here (\$43,805 as tested) nor the \$42,600 starting price for our RAV4 (\$49,831 as tested) is easy to swing for a vast swath of average American families,

but rebates exist to reduce the burden. Most notably, the Toyota qualifies for a \$7,500 federal tax credit, and the Outlander qualifies for \$6,587 in federal dollars. This isn't money in your pocket, per se, but it does significantly reduce your tax liability to Uncle Sam. Most states, many municipalities, and some utility companies also offer their own tax credits and incentives for a PHEV purchase, some of which actually do put cash in your hand.

Let's Talk Power

Under the RAV4's hood resides a 2.5-liter inline-four producing 177 horsepower and 165 lb-ft of torque. The engine teams up with the typical Toyota Hybrid Synergy Drive motor and generator in front that generates 134 hp and 199 lb-ft, which helps drive the front wheels via a planetary e-CVT. A rear electric motor, this one making 40 hp and 89



This engine's 177 hp is only part of the story.

lb-ft, powers the rear axle. Total output for the RAV4 Prime is rated at 302 horsepower. (Because of how the power and torque curves differ between engines and motors, not to mention the differing speeds they operate at as road speeds vary, you can rarely add the peak output figures to come up with the total output.)

Although that meaty power rating is pretty appealing on its own, the RAV4 Prime also serves up one of the highest EPA-rated driving ranges of any plug-in hybrid, thanks to its large battery and efficient powertrain. With a full battery, the Toyota is said to go 42 miles before the engine kicks in. With the four-cylinder in the mix, total driving range is 600 miles. As for fuel efficiency with all powertrain components in play, the EPA rates the RAV4 at 94 mpg-e combined. If you never bother to plug in the Prime—which strikes us as a suboptimal choice—the EPA says you'll get 38 mpg combined.

A new Nissan Rogue-based 2022 Mitsubishi Outlander is on the horizon, but Mitsubishi didn't neglect the 2021 model. Despite being near the end of its now nine-year life cycle, this year Mitsubishi replaced the previous 2.0-liter inline-four with a 2.4-liter version, and it upgraded the electric motors and battery pack, too. Working the front wheels, the

GAP

WORDS CHRISTIAN SEABAUGH
PHOTOGRAPHY RENZ DIMAANDAL

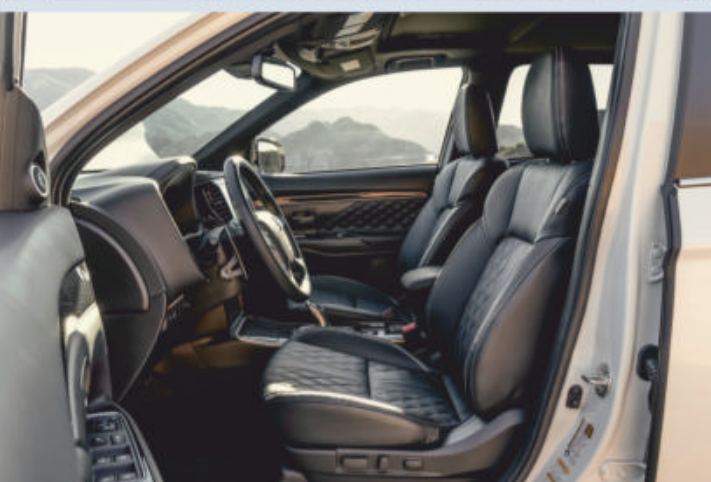




Mitsubishi Outlander PHEV



Toyota RAV4 Prime



new electric motor is good for 80 horses and 101 lb-ft of twist. The rear motor produces 94 horsepower and 144 lb-ft of torque. The bigger engine makes 126 horsepower and 148 lb-ft but usually just spins a generator. Like the latest Honda hybrids, it connects directly to the front wheels under certain conditions above 40



mph. The Outlander's peak system output of 221 horsepower can only be felt at high speeds; most of the time you only feel the additive power and torque of the two electric motors.

With a 13.8-kWh battery pack on board, the Outlander PHEV's 24-mile EPA-rated electric-only range would be impressive if it weren't for the RAV4 Prime's long legs. The Outlander PHEV has a total driving range of 320 miles before needing fuel and/or a recharge, which also trails the RAV4 Prime's numerical might. When you use the battery most of the time, the plug-in Outlander is rated at 74 mpg-e combined; shun power outlets for good, and it returns 26 mpg combined.

Which Interior Is Better?

Naturally, we spent plenty of time getting familiar with the innards of our SUV pair. The Mitsubishi attempts to cover its age in unexpected ways. "Surprising," associate editor Eleonor Segura said of the Outlander's well-crafted quilted leather. "I can honestly say I didn't expect the seats to show such attention to detail. That the detailing spreads to the door



panels is neat, too." But look closely, and signs of the Outlander's near-retiree status emerge. Plasticky switchgear and an outclassed infotainment system betray it as a generation (or two) older than the Toyota. Its packaging isn't as clever, either, offering less cargo capacity and head-, shoulder-, and front legroom than the RAV4.

So the RAV4 is roomier, and its cabin is also one of Toyota's more satisfying among its current lineup, with neat, texturized HVAC knobs; a big, easy-to-read infotainment display; and plenty of storage. We love the dashboard's integrated shelf, for example.



GIVEN THE POWER DISPARITY, IT'S UNSURPRISING THE TOYOTA HAS THE PERFORMANCE EDGE.

Which Is Quicker?

Given the power disparity between the two SUVs, it's unsurprising the Toyota had the advantage in almost all of our instrumented tests. It isn't dignified while doing so, but the Prime will zip from 0 to 60 mph in 5.5 seconds and through the quarter mile in 14.1 seconds at 98.7 mph. "Well, that was unexpected," associate road test editor Erick Ayapana said. "The RAV4 Prime really made me work to control wheel spin, seemingly from the rear axle first, and then the front axle. Regardless, this thing feels strong off the line." The power helped the Toyota on our figure-eight handling course, too, where it turned a 27.0-second lap at an average of 0.65 g.

The Outlander was much more sedate, accelerating to 60 mph in an uneventful but respectable 8.5 seconds and through the quarter mile in 16.7 seconds at 83.9 mph. Its figure-eight lap of 28.0 seconds at an average of 0.59 g once again lagged behind the Toyota, but the Mitsubishi at least managed to outbrake the RAV4 in our 60-0-mph test, needing 125 feet versus the Toyota's 127.

What About in the Real World?

Outside the confines of the test track, the Outlander and RAV4 are more evenly matched. We tested the duo on one of our standard driving routes, choosing one long enough to deplete their batteries and ensure at least half the distance was done in hybrid mode. We started with full batteries thanks to an Electrify America station conveniently located along our loop.

On the topic of charging, both the Outlander and RAV4 include a standard J1772 plug, which takes AC electricity from your 120-volt Level 1 wall outlet or a 240-volt Level 2 source and uses an onboard charger to convert the juice to DC and deliver the electrons to the batteries. The Outlander packs a 3.7-kW onboard charger, whereas the RAV4 Prime comes standard with a 3.3-kW unit.

Generally speaking, the higher a charger's kilowatt rating, the faster the charge, and the onboard chargers in the Toyota or Mitsubishi require roughly three hours of tethering to achieve a full charge from empty. However, the RAV4 Prime XSE's \$3,765 Premium package substitutes a 6.6-kW onboard charger, which would halve the charging speed at Level 2 voltage. Advantage Toyota, it would seem.

Not so fast (charging), actually. The Outlander PHEV has a clever trick up its sleeve: a standard Level 3 CHAdeMO DC fast charger, making it one of very few plug-in hybrids capable of using

COMPARISON



The Escape PHEV's 102 mpg-e is among the best in the segment. Only the Hyundai Ioniq (119) and Kia Niro (105) achieve better.

BY THE NUMBERS

2021 Ford Escape PHEV vs. Subaru Crosstrek Hybrid

With so many plug-in hybrids to choose from on the U.S. market—30 as of this writing—option paralysis is a real challenge to overcome when deciding which one to park in your driveway. It also presented a bit of a problem in choosing competitors for our comparison test of plug-ins; we ultimately decided compact SUVs were a reasonable starting point given the segment's popularity. On the invite list: the Toyota RAV4 Prime, Ford Escape PHEV, Subaru Crosstrek Hybrid, and Mitsubishi Outlander PHEV.

Alas, the Escape PHEV and Crosstrek Hybrid were unavailable. Ford delayed U.S. deliveries of its model due in part to a recall in Europe, while Subaru simply didn't have a Crosstrek Hybrid available in its media fleet. The pluggable Crosstrek and Escape remain notable entries in the segment, though, so let's break down their powertrains, pricing, efficiency, and more.

The 2021 Subaru Crosstrek Hybrid starts at \$36,395 and is eligible for a \$4,502 federal tax credit, as well as potential additional incentives on the state and municipal levels. (It's worth noting Subaru only sells the Crosstrek Hybrid in the ZEV states of California, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont.) It combines a 2.0-liter Atkinson-cycle flat-four

engine with two electric motors, one of which provides propulsion while the other acts as a starter-generator and sends energy to the 8.8-kWh battery pack. These motors are integrated into a continuously variable automatic transmission that sends the total system output of 148 horsepower and 149 lb-ft of torque to all four wheels.

According to the EPA, the Crosstrek Hybrid can go 17 miles on electricity alone, scores 90 mpg-e combined in PHEV mode, and can achieve 35 mpg combined if it's never plugged in and left to operate purely as a conventional hybrid. With the battery fully charged and a full tank of gas, it can deliver up to 480 miles of total driving range. A Level 1 (120-volt) charger replenishes its depleted battery pack in five hours; a Level 2 (240-volt) station slashes that time to roughly two hours.

The 2021 Ford Escape SE Plug-In Hybrid (2020 model pictured) carries a starting price of \$33,895 and a qualifying federal tax credit of \$6,843 in addition to possible state and municipal bonuses. Unlike the Crosstrek, Outlander PHEV, and RAV4 Prime, the Escape PHEV is only available with front-wheel drive. Its powertrain teams a 165-hp 2.5-liter I-4 with two motor generators, a planetary e-CVT, and a 14.4-kWh lithium-ion battery pack. The setup produces a combined 221 horsepower.

The Ford notches an estimated EPA rating of 102 mpg-e (41 mpg if never plugged in), as well as an impressive 37 miles of pure electric driving range. In terms of charging an empty battery, a Level 1 (120-volt) outlet will need 10 to 11 hours to finish the job, whereas a Level 2 (240-volt) charger can do it in as little as three hours and 20 minutes. Finally, the Escape PHEV has an 11.2-gallon gas tank compared to the Crosstrek Hybrid's 13.2-gallon unit. As of this writing, we're still awaiting word as to when the Escape PHEV will hit dealers in the States. **Eleonor Segura**



The Subaru Crosstrek Hybrid falls short of the Ford in most efficiency measures, but its smaller battery recharges twice as quickly.



COMPARISON

Unlike plug-ins of yesteryear, there's little visual differentiation between these PHEV SUVs and their gas versions.



quicker-charging infrastructure reserved for pure electric vehicles. Although CHAdeMO is on the slower end of fast-charging technology, delivering a max of 50 kW of DC electricity straight to the battery by bypassing the onboard charger, this setup is capable of replenishing the Outlander's battery from empty to full in less than an hour. (It's worth mentioning that just as HD DVD lost the format war to Blu-ray, CHAdeMO has lost to the more common and quicker CCS fast-charge system, which can deliver up to 350 kW.)

On the road, the Outlander PHEV is nice enough to drive, which sounds like faint praise but is truly surprising given how mediocre the gas-only version is. The Mitsubishi's power delivery deserves much of the credit for its better manners. Its accelerator response is fairly aggressive, which couples with the surge of low-end torque from its twin electric motors to make the Outlander feel quicker than it is, especially around town. That said, passing power is sorely lacking at highway speeds, and igniting the engine helps less than its sound suggests. That's because the battery alone can't deliver full power, so the engine starts and runs at its twin power/torque-peak of a noisy 4,500 rpm to generate the

needed power—which still tallies to just 174 hp until the engine connects to the wheels and starts pulling its weight.

The Mitsubishi's ride quality and chassis performance aren't as modern in execution as its powertrain. Despite using unibody construction, the Outlander PHEV feels like an old-school body-on-frame SUV as it lists in turns and shudders over bumps. The steering has very little feel, but to the good, the mighty electric motor at the rear imparts a sporty impression as it helps power the Outlander through bends accurately enough given the other handling demerits.

Compare this to the Toyota, which somehow gets even better in the real world. With a full charge, the RAV4 feels a lot like a contemporary electric SUV. Its motors make prodigious power and give the Toyota plenty of scoot both around town and on the highway without having to resort to firing up its four-pot. Although even harsher-sounding at full throat than the Mitsubishi's four, when the engine does fire up, its presence is always directly additive to the electric motors, and the Prime feels properly quick for the segment. The RAV4 Prime is also the first Toyota we've ever driven in which the "EV" button (which switches the powertrain to full-electric mode) actually does what it's supposed to.

Although the RAV4's powertrain is seriously impressive, its ride and handling are typical Toyota, which is to say the suspension tuning is generally agreeable. Still, as road test editor Chris Walton put

Are PHEVs the Worst Polluters?

The answer depends a little on the PHEV and a lot on the driver. Series PHEVs and series/parallel PHEVs with powerful motors like the RAV4 Prime function like EVs, never firing their engines until the battery empties. These can be legit green machines if drivers plug in enough to run primarily on electricity. With their batteries discharged, they're just less efficient hybrids. But PHEVs (like the Outlander) that must fire their engine to deliver full acceleration or maintain highway speeds can become super-polluters if the engine cycles on and off multiple times per trip, allowing time for the catalytic converter(s) to cool and release harmful emissions upon each restart. And using a charge mode, where the engine tops up the battery, causes it to work harder and emit more CO₂ than would an internal combustion powerplant in a nonhybrid. **Frank Markus**



it, the setup is "all spring and no damper," meaning the impact from an imperfection lasts long after you've passed over it. The RAV4's steering is surprisingly tactile, however, with a feel and precision lacking from most compact SUVs.

Which Is the Better PHEV SUV?

Ultimately, both the Outlander PHEV and RAV4 Prime are impressive achievements, offering pain-free ways to bridge the gap between your last gas-powered





SCAN THIS CODE
to see how the Escape
fared against the
Toyota RAV4 Prime.



SUV and your first electric one. But one is clearly better than the other.

In second place is the Outlander. While outclassed by the Toyota in range, efficiency, and performance, the Mitsubishi put up a valiant fight thanks to the zippy feel of its electric motors, its friendlier sticker price, and its quick-charge capability. We can understand why it's the best-selling PHEV in the world, and the impression it left has us looking forward to the all-new version coming soon.

Which means the RAV4 Prime is our winner. This RAV4 is a true have-your-cake-and-eat-it-too SUV. It's efficient thanks to its seamlessly integrated powertrain. It's long-legged, thanks to its large battery pack and miserly engine and motors. And it's also properly quick, reasonably fun to drive, comfortable, and spacious. Although it's a shame the rival Ford Escape PHEV and Subaru Crosstrek Hybrid were unavailable for this party, it's safe to say the RAV4 Prime is the plug-in SUV to beat. ■

Second Place:
Mitsubishi Outlander PHEV

A fast-charging trick can't make up for this pleasant but aging plug-in's packaging, handling, and powertrain deficiencies.

First Place: Toyota RAV4 Prime

Big power, smart interior flourishes, and efficiency advantages put this one over the top. The RAV4 is the one to get.

*During EPA blended-PHEV (charge-depleting) mode testing, with vehicles set to their default drive and brake-regeneration modes.

POWERTRAIN/CHASSIS	2021 Mitsubishi Outlander GT PHEV S-AWC	2021 Toyota RAV4 Prime XSE AWD PHEV
DRIVETRAIN LAYOUT	Front-engine, AWD	Front-engine, AWD
ENGINE TYPE	Atkinson-cycle I-4, alum block/head, plus front/rear AC permanent-magnet electric motors	Atkinson-cycle I-4, alum block/head, plus front/rear AC permanent-magnet electric motors
VALVETRAIN	DOHC, 4 valves/cyl	DOHC, 4 valves/cyl
DISPLACEMENT	144.0 cu in/2,360cc	151.8 cu in/2,487cc
COMPRESSION RATIO	12.0:1	14.0:1
POWER (SAE NET)	126 hp @ 4,500 rpm (gas); 80 hp (front)/94 hp (rear) elec motors; 221 hp (comb)	177 hp @ 6,000 rpm (gas); 179 hp (front)/53 hp (rear) elec motors; 302 hp (comb)
TORQUE (SAE NET)	148 lb-ft @ 4,500 rpm (gas); 101 lb-ft (fr)/144 lb-ft (rr) elec motors	165 lb-ft @ 3,600 rpm (gas); 199 lb-ft (fr)/89 lb-ft (rr) elec motors
REDLINE	Not indicated	Not indicated
WEIGHT TO POWER	19.5 lb/hp	14.5 lb/hp
TRANSMISSION	1-speed automatic, front and rear	Front: cont variable auto, rear: 1-speed auto
FINAL DRIVE RATIO	9.66:1 (fr elec), 7.07:1 (rr elec), 3.43:1 (gas, 40-45 mph+)	N/A
SUSPENSION, FRONT; REAR	Struts, coil springs, anti-roll bar; multilink, coil springs, anti-roll bar	Struts, coil springs, anti-roll bar; multilink, coil springs, anti-roll bar
STEERING RATIO	14.7:1	14.4:1
TURNS LOCK TO LOCK	2.8	2.6
BRAKES, F; R	11.6-in vented disc; 11.9-in disc, ABS	12.9-in vented disc; 12.4-in vented disc, ABS
WHEELS	7.0 x 18-in cast aluminum	7.5 x 19-in cast aluminum
TIRES	225/55R18 97H Bridgestone Ecopia H/L 422 Plus (M+S)	235/55R19 101V (M+S) Yokohama Avid GT
DIMENSIONS		
WHEELBASE	105.1 in	105.9 in
TRACK, F/R	60.6/60.6 in	62.6/63.3 in
LENGTH X WIDTH X HEIGHT	184.8 x 70.9 x 67.3 in	180.9 x 73.0 x 67.2 in
GROUND CLEARANCE	7.3 in	8.3 in
APPROACH/DEPART ANGLE	19.5/21.0 deg	18.6/21.4 deg
TURNING CIRCLE	35.6 ft	37.4 ft
CURB WEIGHT (F/R DIST)	4,306 lb (53/47%)	4,372 lb (56/44%)
TOWING CAPACITY	1,500 lb	2,500 lb
SEATING CAPACITY	5	5
HEADROOM, F/R	39.9/38.1 in	37.7/39.5 in
LEGROOM, F/R	40.9/37.9 in	41.0/37.8 in
SHOULDER ROOM, F/R	56.4/56.0 in	57.8/56.4 in
CARGO VOLUME, BEH F/R	62.8/30.4 cu ft	63.1/33.4 cu ft
TEST DATA		
ACCELERATION TO MPH		
0-30	3.3 sec	2.0 sec
0-40	4.7	3.0
0-50	6.4	4.1
0-60	8.5	5.5
0-70	11.3	7.1
0-80	15.1	9.0
0-90	—	11.4
0-100	—	14.5
PASSING, 45-65 MPH	4.3	2.8
QUARTER MILE	16.7 sec @ 83.9 mph	14.1 sec @ 98.7 mph
BRAKING, 60-0 MPH	125 ft	127 ft
LATERAL ACCELERATION	0.76 g (avg)	0.83 g (avg)
MT FIGURE EIGHT	28.0 sec @ 0.59 g (avg)	27.0 sec @ 0.65 g (avg)
TOP-GEAR REVS @ 60 MPH	N/A	N/A
CONSUMER INFO		
BASE PRICE	\$43,190	\$42,600
PRICE AS TESTED	\$43,805	\$49,831
STABILITY/TRACTION CONTROL	Yes/Yes	Yes/Yes
AIRBAGS	7: Dual front, front side, f/r curtain, driver knee	8: Dual front, front side, f/r curtain, driver knee, passenger knee, front pass thigh
BASIC WARRANTY	5 years/60,000 miles	3 years/36,000 miles
POWERTRAIN WARRANTY	10 years/100,000 miles	5 years/60,000 miles
BATTERY/HYBRID SYS	10 years/100,000 miles	8 years/100,000 miles
ROADSIDE ASSISTANCE	5 years/Unlimited miles	2 years/25,000 miles
FUEL CAPACITY	11.3 gal + 13.8 kWh Li-ion battery	14.5 gal + 18.1 kWh Li-ion battery
TIME TO CHARGE (240V)	4.0 hrs	4.5 hrs
EPA CITY/HWY/ COMB ECON	26/26/26 mpg (gas), 77/71/74 mpg-e* (gas+elec)	40/36/38 mpg (gas), 105/84/94 mpg-e* (gas+elec)
ENERGY CONS, CITY/HWY	130/130 (gas), 44/47 (gas+elec)* kWh/100 miles	84/94 (gas), 32/40 (gas+elec)* kWh/100 miles
CO2 EMISSIONS, COMB	0.75 (gas), 0.26 (gas+elec)* lb/mile	0.51 (gas), 0.21 (gas+elec)* lb/mile
RECOMMENDED FUEL	Unleaded regular, 240-volt electricity	Unleaded regular, 240-volt electricity



Flipping the Switch

A showroom of affordable (and profitable) electric vehicles in all shapes and sizes has long been the holy grail for automakers and regulators alike.

It is a long-standing dance that has gone on for nearly 50 years: Regulators set ambitious emissions-reduction targets with long lead times, the established automakers cry, “Impossible!” then hunker down and either work to defang the mandates or occasionally hit the targets, sometimes ahead of schedule. Solutions to date have been a mix of improving the efficiency of the gas-powered fleet, adding hybrids, and developing a few token electric vehicles sold at a loss to the few buyers who want them. Lather, rinse, repeat.

Automakers have attempted to lure the public into electric vehicles but made little headway. Part of it is confirmation bias: Automakers spend far more on advertising

gas-guzzling SUVs than battery-powered hatchbacks. As a result, pure electric vehicles still account for less than 2 percent of U.S. vehicle sales, and four out of every five of those sales is a Tesla. But is the market poised for change?

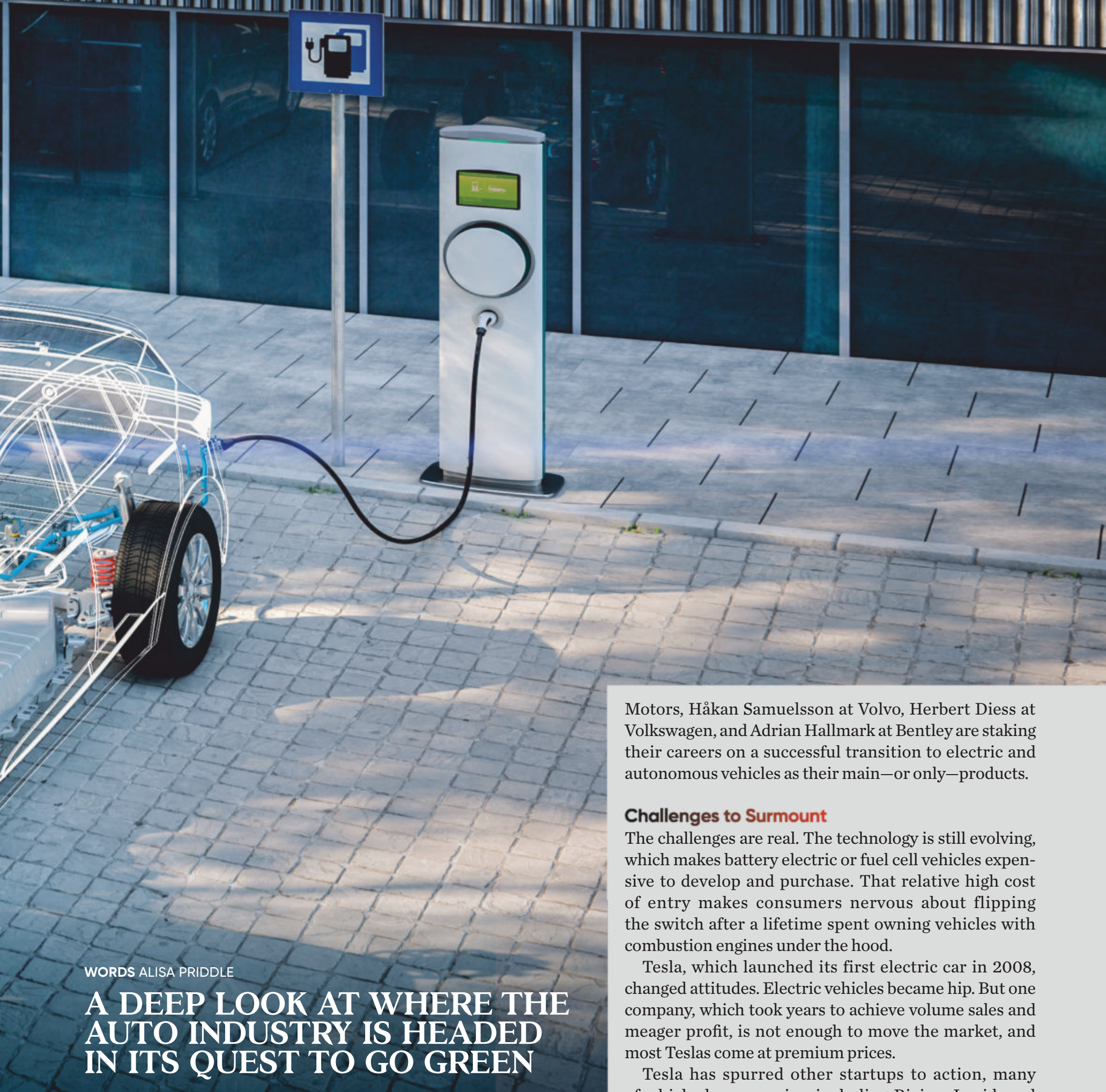
Tipping Point in EV Popularity?

The prize is within grasp as the industry pivots to offer EVs fitted with cheaper and more energy-dense batteries, thus delivering greater range and lower prices that bring parity with gas-powered counterparts ever closer.

“We’ll reach a point in the U.S. where nearly every brand offers modern, compelling battery electric vehicles soon, and that is a clear change,” IHS Markit principal analyst Stephanie Brinley said. To Brinley, this appears to be the tipping point when automaker participation goes beyond building compliance vehicles to meet regulations.

In 2013, the Tesla Model S marked an “astonishing inflection point” for the industry. Eight years later, it faces global competition.





WORDS ALISA PRIDDLE

A DEEP LOOK AT WHERE THE AUTO INDUSTRY IS HEADED IN ITS QUEST TO GO GREEN

The shift makes President Joe Biden's call for the U.S. to achieve a 100 percent clean-energy economy and reach net-zero emissions by 2050 plausible. The target is ambitious, but Biden's timeline is further out than many of the pledges from automakers.

Globally, companies, cities, states, and countries are phasing out or banning new vehicles with combustion engines decades before that. China and Europe are embracing the change more quickly than North America, but in a global industry, all boats will rise with this tide.

Automakers are multitaskers. They work on minor improvements for the next model year while engineering new models to introduce four years out and developing technology that might be decades from reality. And now, more than ever before, designers and engineers are seeing green. CEOs such as Mary Barra at General

GM's Mary Barra is among the many power players pushing the industry forward.



Motors, Håkan Samuelsson at Volvo, Herbert Diess at Volkswagen, and Adrian Hallmark at Bentley are staking their careers on a successful transition to electric and autonomous vehicles as their main—or only—products.

Challenges to Surmount

The challenges are real. The technology is still evolving, which makes battery electric or fuel cell vehicles expensive to develop and purchase. That relative high cost of entry makes consumers nervous about flipping the switch after a lifetime spent owning vehicles with combustion engines under the hood.

Tesla, which launched its first electric car in 2008, changed attitudes. Electric vehicles became hip. But one company, which took years to achieve volume sales and meager profit, is not enough to move the market, and most Teslas come at premium prices.

Tesla has spurred other startups to action, many of which show promise, including Rivian, Lucid, and Nio—not to mention dozens of Chinese companies most Americans have never heard of. Long-established automakers don't want to be left behind, either, like the last buggy whip salesmen of 1920.

This could be the year EV sales take off, with more than a dozen new models expected to join the 20 already on the market in 2020. IHS Markit expects more than 100 nameplates to offer a battery electric option in 2025 and says EV share could more than triple from 1.8 percent of U.S. registrations last year to 9 percent in 2025 and 15 percent in 2030.

Toyota is particularly bullish: EV sales will grow to as high as one in six vehicles sold industry-wide by 2030, said Bob Carter, head of sales for Toyota Motor North America. That would represent more electric Toyotas than the company's Lexus division sells in the U.S.



Worldwide sales of electric vehicles were about 2.5 million last year and seem ready to explode. China is already the world's largest EV market at 1.1 million annual units, up almost 10 percent last year, according to China Passenger Car Association data. China could see EVs rise to 15 percent of its new-car fleet in 2025 and 24 percent in 2030. In Europe, EVs are projected to reach 19 percent in 2025 and 30 percent in 2030, a trend presaged by Norway, where EVs outsold internal combustion vehicles last year thanks in part to hefty financial incentives.

These figures don't include the continued proliferation of hybrids, as electrified powertrains become an increasingly normalized option in the showroom—choose a model, a color, and a powertrain, then grab the keys.

"Relying on incumbent [internal combustion engine] technology for profits has now become high-risk as electric vehicle sales rise and their market share grows from niche to mainstream," David Leggett, automotive analyst at GlobalData, said. GlobalData forecasts 46.1 percent of all new vehicles sold globally will be electrified in some form by 2030. "'Wait and see' is no longer a sensible strategic option. Urgency is required."

Learning Curve for Old and New Carmakers

Efforts by tech companies to get into the electric car business could further shake up an industry already undergoing a seismic transition. Companies like Dyson, Sony, and Apple toyed with making EVs but quickly discovered that status as a nonautomotive titan doesn't mean you know how to mass-produce a car. Even Tesla continues to overcome what Elon Musk has called "manufacturing hell." For its part, Apple realizes it might be easier to have someone else build a car incorporating its tech.

Conversely, conventional automakers that have made vehicles for decades are discovering that although you might be able to assemble a vehicle in your sleep, it doesn't mean you will get the technology right out of the gate. The launch of the Volkswagen ID3, a mass-market EV for Europe, was delayed because it was plagued with software problems. And many mass-production automakers are having issues hitting the range numbers Tesla achieved years ago.

The good news is all automakers, new and old, are getting in the game. Some have created new brands (see Hyundai's Ioniq, among others) and dedicated entire plants to assembling battery-powered models. And the potential pie is enormous. "From my kids' kids' kids' perspective, we as a planet need to electrify as fast as possible," RJ Scaringe, CEO of electric vehicle startup Rivian, said. "It's important the entire industry start to make this shift. We need to replace 100 million cars a year, about 1.5 billion on the planet, as quickly as possible."

Smorgasbord of Electric Vehicles Coming

The number of brands offering EV options in the U.S. will grow from 16 now to at least 40 in 2025, and the vehicles will cover a wide range of segments and price points.

For GM, the Chevrolet Bolt has proved more successful than the nearly forgotten EV1 of the '90s, but the real

buzz is on the 2022 GMC Hummer EV full-size electric pickup and SUV models and the other mainstream EVs in the works for all GM brands.

Ford has the 2021 Mustang Mach-E electric crossover, to be followed by an electric F-150 pickup and yet more EVs for both Ford and Lincoln. And look for Jeeps crawling silently over rock piles in the future, as well as EVs planned for all 14 Stellantis brands.

Luxury models from Audi, BMW, and Porsche will have competition as Bentley and Jaguar go fully electric. Volvo was among the first to commit; Nissan will give the well-established Leaf a sibling in the Ariya SUV. Mini once again has an electric car, while the Korean marques have big plans for a new bespoke electric platform. (For more on each automaker's plans, see page 58.)

Settling Range Anxiety

Running out of juice remains top of mind for many buyers who worry where the next charging station may be, this despite most new models targeting a range of 300 miles on a single charge. So although many people might wonder, as former GM and Chrysler exec Bob Lutz once suggested, whether there's "a can of electricity to put in" if they run out of power, automakers tout studies showing the daily habits of most drivers occupy a fraction of current range figures. That will ring even truer with future vehicles that aim for 500 miles on a single charge, with hopes that work on solid-state batteries will make that the norm by mid-decade.

Most EV owners today charge their vehicles at home or work, but concerns persist about the adequacy of a nascent public charging infrastructure. This is now everyone's issue, with both the private and public sectors working to expand the network. President Biden promised to deliver more than 500,000 charging stations as part of an infrastructure upgrade. (We think he means individual charging plugs, as there are only 168,000 gasoline stations in the U.S., according to fueleconomy.gov.) But at present, there are only about 38,000 public charging stations in the U.S. with 97,000 plugs, according to the Alternative Fuels Data Center. About a third are in California. Broad coverage will take time, but momentum is building.

Tesla set the pace early on and has more than 23,000 charging stalls at almost 2,600 Supercharger stations globally, with more than half of them in North America. But those only work with Tesla vehicles.

ChargePoint is the nation's largest network thanks to more than 25,000 public stations and 70,000 plugs in the U.S., and it has alliances with EVgo and Electrify America. Electrify America is investing \$2 billion over 10 years to expand its open DC fast-charging network and will have about 800 stations with 3,500 chargers in 45 states by the end of the year. GM and its EVgo partner are adding 700 stations with 2,700 plugs over five years; EVgo already has more than 1,200 chargers.

Porsche and Rivian plan to build their own networks. Efforts are also underway to aggregate these charging networks into a single customer account for payment.

All automakers, new and old, are getting into the game, and the potential pie is enormous.

Government and Regulations

Governments are major players in motivating the public to embrace electric vehicles. In the U.S., President Biden began signing climate-related executive orders immediately upon taking office, among them a directive to electrify the federal fleet of about 650,000 vehicles, invest in about 550,000 chargers, strengthen the domestic supply chain for crucial technologies and raw materials, create 1 million jobs in these areas, and offer more incentives for consumers to buy EVs.

Biden has also ordered an agency review to establish “ambitious, job-creating fuel economy standards.” Rules for 2021–2026 passenger vehicles are due by July and are expected to return to Obama-era standards.

“The Biden administration sees climate change as an existential threat,” Kristin Dzikczek, vice president of research for the Center for Automotive Research, said. The president wants to accelerate the industry’s planned transition to electrification using the “carrots” of planned investments in clean energy, charging infrastructure, EV and battery R&D, U.S. manufacturing, and EV purchase incentives. Meanwhile, there are “sticks” in the form of more stringent fuel economy and greenhouse gas emissions regulations.

“This administration has sent a strong signal that achieving the country’s climate goals must also achieve their goals for ‘Made in America’ and expanded labor rights,” Dzikczek said. “Automakers and suppliers will likely see climate change, increased domestic manufacturing, and worker rights addressed in future federal government grants, loans, and [contracts].”

At the state level, 16 states follow stricter California Air Resources Board emissions statutes. California new-vehicle registrations dropped in 2020, but EV and plug-in hybrid sales increased. CARB spokesman Dave Clegern is bullish on achieving future ZEV goals.

Under a plan formulated by California Governor Gavin Newsom, the state will ban sales of new gas-powered passenger vehicles starting in 2035 and has a goal of 5 million plug-in hybrid and electric vehicles on the roads by 2030. Massachusetts has announced similar plans, and legislation introduced in Washington state in January would mandate all new passenger vehicles there be electric starting with the 2030 model year. These three examples will help put the U.S. more in line with countries worldwide pushing for a 2030 phaseout of gas vehicles to meet their carbon-reduction goals. A similar nationwide plan is in a nascent state in the U.S. Congress.

Japan wants to eliminate sales of gasoline-powered vehicles by the mid-2030s. A number of European countries are pushing to ban sales of new vehicles that use fossil fuels. The U.K. ban takes effect in 2030; Denmark, Sweden, Germany, and France are also among more than a dozen countries adopting similar mandates, and cars with combustion engines now make up fewer than half the newly registered vehicles in Iceland.

“Achieving the country’s climate goals must also achieve their goals for ‘Made in America.’”



Power companies are also getting in on the action. The Edison Electric Institute said it is on track to electrify a third of its fleet vehicles by 2030 and will continue to work to create the needed infrastructure. The EEI represents all U.S. investor-owned electric companies.

“There really is no alternative for car companies as lawmakers across the world start to plot mandating fossil fuel-powered vehicles out of the market,” GlobalData’s Leggett said. “Electrification is an expensive proposition for vehicle manufacturers, but they are nevertheless concluding they must take the investment hit to be well positioned competitively later this decade when the end for new internal combustion engine vehicle sales will be in sight in a number of markets.”

Supply Chain Issues

The auto industry is no stranger to supply issues. In a recent example, the 2011 earthquake in Japan damaged the world’s only supply of the pigment used in metallic paint, forcing U.S. plants to stop vehicle production. This year saw a shortage of semiconductor chips, affecting the production of both conventional and electric vehicles; some plants had to hit pause and sit on partially assembled vehicles while awaiting components.

Other potential supply issues involve procurement of vast amounts of lithium for batteries, as well as rare earth elements known as lanthanides necessary for magnets used in motor-generators. And while automakers boast technological gains that help reduce the per-kWh cost of battery packs, raw material costs remain volatile.

In 2013, the price per metric ton of battery-grade lithium was \$6,500, but by 2018 it had leapt to \$17,000. The cost dropped to about \$8,000 in 2020 before rebounding again this year, according to statista.com.

Raw materials extraction typically occurs in frenemy nations such as China, poverty-stricken countries such as Bolivia, or strife-torn nations such as Congo or Zimbabwe, all of which come with politico-economic or moral costs. Although the U.S. has mining sites for rare earths—providing a transition occupation for lost coal mining jobs—strict environmental regulations have stifled their development. That represents a Catch-22 for those pushing for “clean” cars.

The Biden “Made in America” initiative includes a plan to create 1 million new jobs involving electric vehicles and the EV industry. That could prove difficult, however. Electric vehicles have a third fewer moving parts than a conventional vehicle, and fewer parts means less labor. Conventional vehicles require thousands of workers to make combustion powertrains and their parts.

Regardless, the march to an all-electric future is underway, and the industry has embraced it with a new vigor. If the grandiose promises and plans come to fruition, consumers will be offered EVs of all descriptions and at varied price points. As prices and charge times come down and range goes up, consumers will be more likely to buy in. ■



ELECTRIC COMPANIES

A snapshot of key automakers and their electric vehicle status and strategy



BMW

Although its initial EVs were either compliance cars (i3, Mini EV) or wacky science projects (i8), BMW is now serious about electrification. Coming are the i4 fastback and 2022 BMW iX midsize crossover EVs, as the automaker wants electrified vehicles to account for a quarter of its U.S. sales by 2025 and half of global sales by 2030.



BMW i4



Daimler/ Mercedes-Benz

Mercedes created the EQ subbrand solely for electric vehicles, with global launches of the EQS sedan, EQA and EQB small crossovers, and EQE midsize sedan coming this year. These are among 10 new electrified models from Mercedes in 2021, including a slew of hybrids. The U.S. will not get every new EQ model, and Mercedes has not set an expiration date for its combustion engines yet.



Ford

Ford is doubling its investment in electric vehicles to \$22 billion by the end of 2025. All its passenger vehicles will offer some form of electrification by mid-2026, and two-thirds of its commercial vehicles will be electric by 2030. An electric F-150 pickup, available in mid-2022, follows the 2021 Ford Mustang Mach-E. In Europe, Ford will phase out gas-powered cars by 2030 and use VW's MEB electric vehicle platform to bring new EVs to market from retooled Ford plants starting in 2023.



General Motors

GM announced plans to spend \$27 billion over five years and introduce 30 electrified vehicles globally by 2025. The automaker hopes to stop selling vehicles with gas or diesel engines by 2035. In addition to the Chevrolet Bolt and 2022 Bolt EUV SUV, the portfolio will include a 2022 GMC Hummer EV full-size pickup truck and its SUV sibling, an electric Chevy pickup, and crossovers for all four GM brands.



Cadillac Lyriq



Jaguar Land Rover

Jaguar has pledged to sell only EVs starting in 2025; all future models will be built exclusively on an electric vehicle architecture, with most rolling out of the Solihull plant. That is a big leap from just the I-Pace crossover, but that's what spending \$3.5 billion a year on R&D gets you. Land Rover will get six new electrified vehicles over the next five years. The first fully battery-powered Land Rover is due in 2024, with that brand's lineup going fully electric by 2039.



Kia

Kia's lineup alone calls for 11 electrified models by 2026, including seven dedicated EVs on the E-GMP architecture. The goal is to sell 1.6 million electrified vehicles (880,000 pure electric) a year by 2030, accounting for 40 percent of its total sales. The first dedicated EV, the EV6, launches later this year to join the Niro EV already on sale.



Kia HabaNiro concept



Honda

Honda needs to play catch-up, and new CEO Toshihiro Mibe will accelerate the company's move to EVs, including its partnership with GM that will birth a crossover for Honda and an undetermined EV for Acura. Honda wants two-thirds of its sales to be battery electric or hybrid vehicles by 2030.



Hyundai

Hyundai wants to sell 1 million EVs a year globally by 2025 between the Hyundai, Kia, Genesis, and newly established EV-only Ioniq brands, using the Electric-Global Modular Platform (E-GMP). The arrival of 23 electrified models starts with the stylish Ioniq 5 midsize electric SUV, which offers a 298-mile range and arrives in the U.S. this summer. The Ioniq 6 electric sedan and Ioniq 7 large crossover will follow. Hyundai entered talks with Apple about assembling vehicles that would see the tech giant enter the EV market, but no deal had been inked at press time.



Nissan

All new vehicles in key markets will be electrified by the early 2030s with a goal of carbon neutrality by 2050. Nissan is working on solid-state batteries for pure EVs while also working to improve its e-Power hybrid technology. The Leaf company is adding the Ariya compact electric SUV this year; there are plans for eight EVs by the end of the year in overseas markets, with a goal of 1 million annual EV sales eventually.



Nissan IMx KURO concept



Stellantis (formerly FCA)

FCA merged with PSA Group in January to create Stellantis, a company with 14 brands that currently sell 29 electrified vehicles globally. New CEO Carlos Tavares said every new vehicle launched until 2025 will have an electrified variant, starting with 10 new entries this year. Many are plug-ins, such as the Chrysler Pacifica PHEV, the Jeep Wrangler 4xe, and forthcoming variants of the Jeep Grand Cherokee, Wagoneer, and Compass. By 2025, Stellantis will have one EV version of every newly launched global model.



POINT YOUR
PHONE HERE
for more about
some of the future
models mentioned
in this story.

Polestar Precept concept



Subaru

Subaru has stated it wants an electric or hybrid version of every vehicle in its lineup, but details aren't much firmer than that. The Crosstrek Hybrid is the only electrified model for sale in the United States.



Subaru Crosstrek Hybrid



Tesla

Tesla's 79 percent EV market share is under siege, but CEO Elon Musk and his firm are still poised for growth. The Model S, X, 3, and Y soon will be augmented by the wild, stainless steel Cybertruck. A high-end Roadster a \$25,000 model, and even a semi truck are still promised.



Tesla Model 3



Toyota

Between now and 2025, Toyota will use the e-TNGA platform to launch an electric subcompact crossover, a compact sedan, a people hauler, and a midsize SUV. The automaker will continue to offer myriad hybrids and plug-in hybrids, believing they are as beneficial to the environment as BEVs for some customers, depending on region and use.



Toyota RAV4 Prime



Volkswagen

The Volkswagen Group's EV push is the largest among mainstream automakers, with the company investing about \$42 billion over the next five years to remove the stain of Dieselgate and reform itself as an electrified car company. The group expects to launch 70 all-electric models across all its brands by 2030, among them the recently introduced ID4, as well as about 60 hybrid variants. Its ambitious targets include building 26 million EVs and hybrids this decade.



Polestar

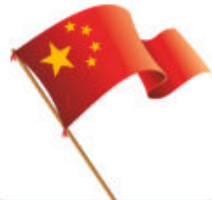
Volvo and Polestar

Volvo was one of the first brands to commit to an EV future, announcing in 2017 that all new models from 2019 on would be either fully electric or hybridized. The target is to sell 1 million such vehicles by the end of 2021, with offerings to come from Volvo and its adjacent Polestar EV brand. Today, Volvo is on track to shift half of its sales to fully electric vehicles by 2025; CEO Håkan Samuelsson wants Volvo to be electric-only by 2030.



Apple

The prospect of an electric car from Apple is a tasty idea that has resurfaced periodically since 2015. Such a car has the potential to truly disrupt the industry. The latest intel surrounds recent talks with Hyundai and Kia to help develop and potentially manufacture an electric autonomous vehicle, but those discussions have yet to result in a deal. Apple has, over the years, approached other automakers and has explored going it alone, but it seems to be more comfortable developing software that can be installed in a vehicle another automaker builds.



China, the Country

There are literally dozens of Chinese electric vehicle manufacturers, including Nio, Byton, Xpeng, and Geely, though how many will enter the U.S. market remains to be seen.



Byton K-Byte



Lordstown

Until recently, Lordstown looked like another compelling startup. It bought a shuttered GM plant and claimed about 100,000 electric work trucks were presold to commercial customers. At press time, reports suggest Lordstown misrepresented its order book, which the company has denied.



Lucid

The Lucid Air is an impressive first offering from this electric vehicle startup, and an SUV variant is planned for 2023. Lucid claims a mind-blowing range of more than 500 miles on a single charge, which could be a game-changer for consumers—and the industry.



Rivian

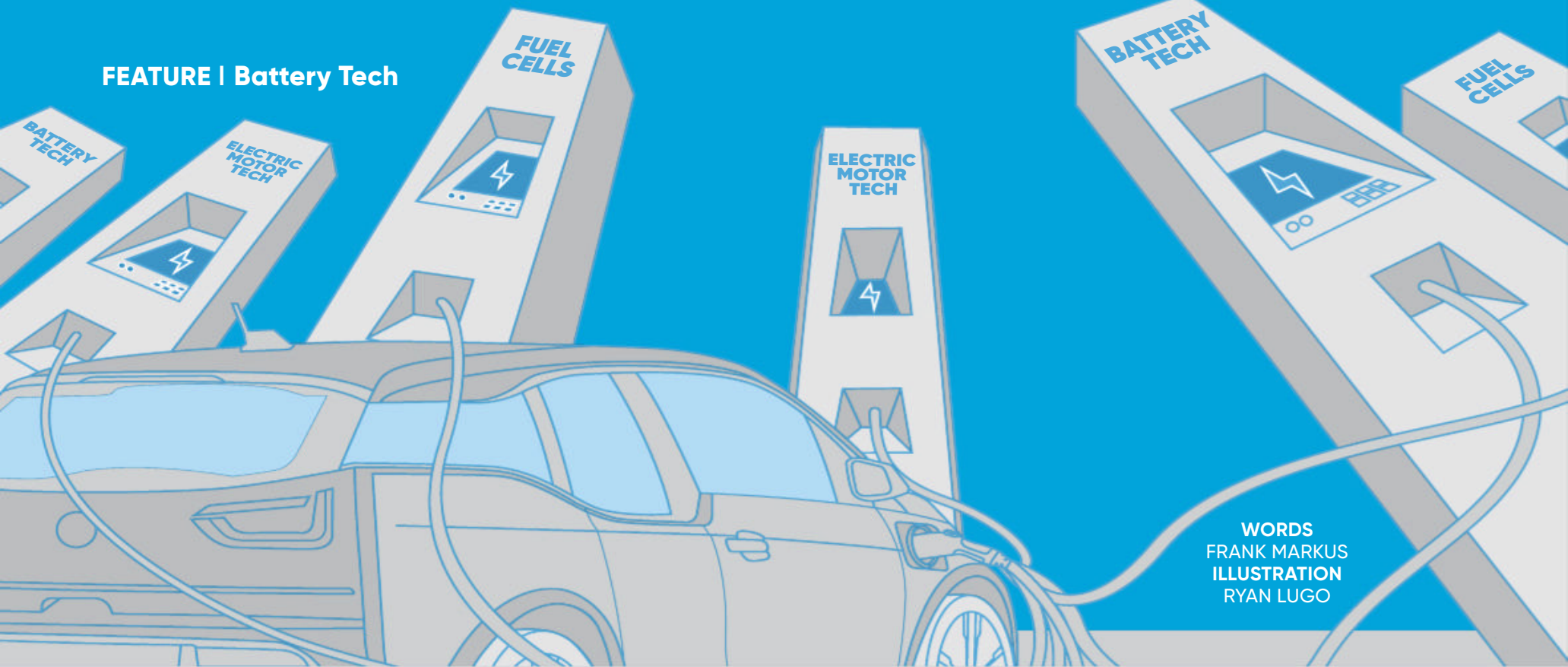
Production of the R1T electric pickup, the R1S three-row SUV, and delivery vans for Amazon starts this year, with more models still to come. Despite piles of funding and promising products, Rivian remains a startup, with all the challenges that entails.



Rivian R1S



Hypothetical
Apple Car



WORDS
FRANK MARKUS
ILLUSTRATION
RYAN LUGO

Green Power

TECH TRENDS TO IMPROVE RANGE, COST, AND ENVIRONMENTAL IMPACT

With most crystal balls indicating an impending mad dash toward electric propulsion, the R&D community is working overtime to solve the thorny problems limiting the market penetration of plug-in vehicles to around 4 percent of global passenger vehicle sales: not enough range or raw materials, and too much mass and cost. Here are some key advances to watch for in battery, fuel cell, and motor technology.

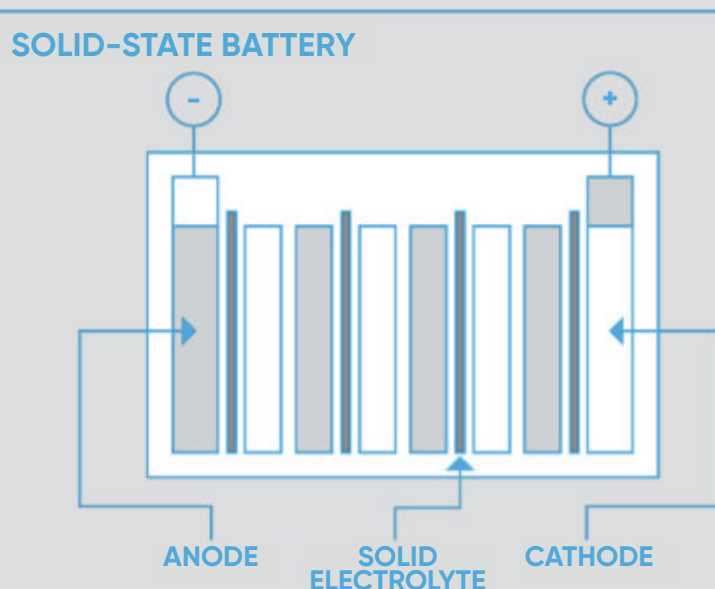
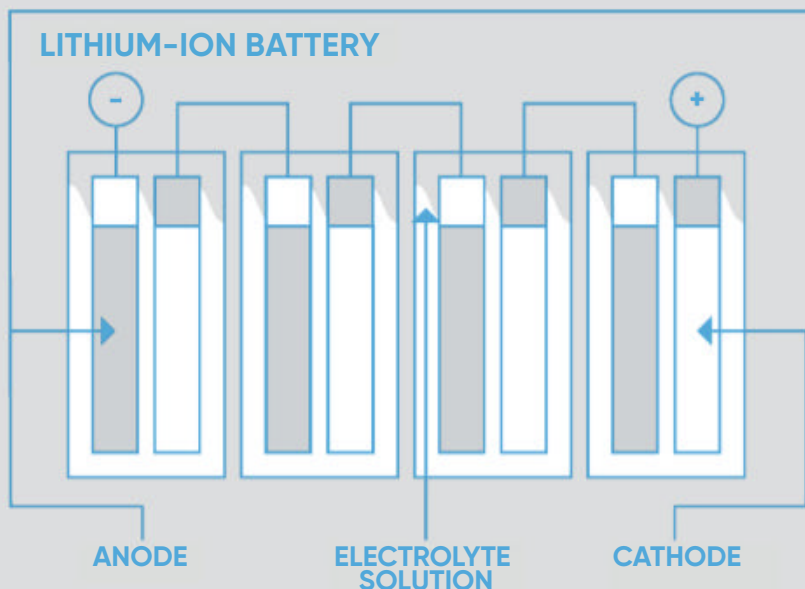
Battery Tech Today's lithium-ion batteries mostly use lithium nickel manganese cobalt oxide chemistry with a liquid or gel electrolyte. This stuff can freeze or catch fire, lithium "dendrite" spikes can form and cause a short circuit if the battery is charged too quickly, and cobalt is rare, expensive, and increasingly difficult to source ethically. Lithium iron phosphate chemistry eliminates cobalt and is less prone to overheating and explosion. Lithium manganese oxide also promises better temperature stability and safety. Replacing the graphite electrodes most batteries now use promises to boost energy density, and Tesla has hinted at a new electrode design employing silicon nanowires that could boost gravimetric energy density from today's 254 Wh/kg to 400.

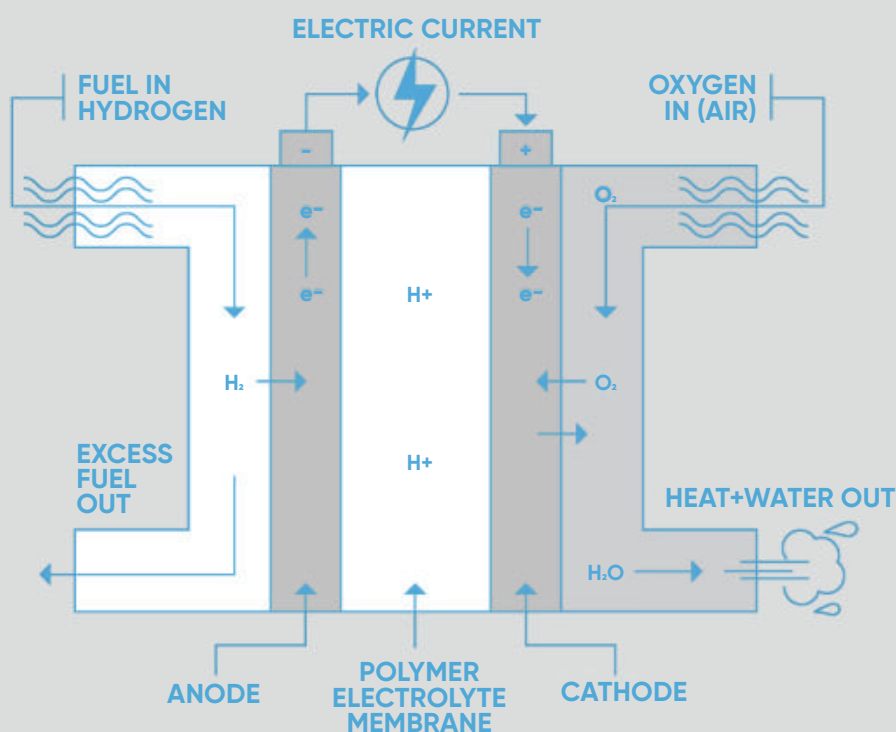
Solid-state batteries using ceramic or other solid electrolytes generally eliminate the fire risk, improve energy density, and permit ultra-fast recharging. QuantumScape's design employs a simple current collector instead of an anode to save weight; prototypes are now delivering 400 Wh/kg, with 600 promised.

Its ceramic separator promises to tolerate recharge rates roughly akin to the time you'd spend filling a gas tank. Solid Power is developing an iron-sulfur chemistry with Ford and BMW; the founder of defunct Sakti3 is working on solid-state batteries for Fisker. And we hear Samsung has a silver-carbon anode solid-state battery in the works.

Another important development is wireless battery management, which promises to replace heavy, costly copper wiring with faster Wi-Fi communication. All GM Ultium batteries will reportedly feature such a system. And on the materials availability front, we're watching efforts to mine the Pacific Ocean's Clarion-Clipperton zone, which is littered with loose potato-sized polymetallic nodules composed of 29.2 percent manganese, 1.3 percent nickel, 1.1 percent copper, and 0.2 percent cobalt—a virtual electric vehicle starter kit.

Fuel Cells Most automotive fuel cells employ a proton-exchange membrane—they're compact and light, and they operate at comfortable temperatures. But they need humidity (which poses water management and freezing challenges), and they require reasonably pure hydrogen. Production vehicles will use these systems for the foreseeable future. Some fuel cells can extract hydrogen from methanol, but these produce CO₂ and are now only used in industrial applications like forklifts. A third type is the flow battery, in which an electrolyte containing





PROTON-EXCHANGE MEMBRANE FUEL CELL

one or more dissolved electroactive elements flows through an electrochemical cell that reversibly converts chemical energy directly to electricity, depleting the electrolyte. The spent electrolyte must then be re-energized, either by plugging in and pumping it backward through the flow cell or by replacing it with fresh electrolyte and re-energizing the electrolyte offboard. Liechtenstein-based NanoFlowcell has developed a compact sports car called the Quantino powered by its flow cell but hasn't announced a production partner. Of perhaps greater interest on the fuel cell front are technological approaches to generating, isolating, storing, and transporting hydrogen.

Electric Motor Tech Abundant research is ongoing to improve the cost, weight, and efficiency of electric motors, too. China produces 95 percent of the rare earth materials in permanent magnets, but funding from the Defense Department's REACT program (Rare Earth Alternatives in Critical Technologies) has produced three promising results: The University of Minnesota developed a strong and inexpensive iron-nitride magnet, the University of North Texas' Ames Laboratory is exploring cerium as a more abundant neodymium replacement, and Argonne National Laboratory has an "exchange spring" magnet in the works, the science of which is utterly inscrutable to non-PhDs (happy Googling).

How magnets are arranged makes a big difference, as well. Most motors place them so their north-south poles radiate out from the axis of rotation, with the gap between rotor and stator parallel to the axis. An emerging class of axial-flux motors, also called "pancake motors," arrange the poles parallel and the gap perpendicular to the rotation axis. This puts the magnets farther away from the axis of rotation, which increases their leverage (and therefore torque), and heat is easier to manage. The axial-flux motor in McLaren's new Artura PHEV is said to be 33 percent more power-dense than the one in its P1 hybrid hypercar.

Reluctance motors can do without permanent magnets or rotor windings altogether, and they deliver high power density at low cost. They are noisier, however, and suffer "torque ripple" (a slight interruption in torque when transitioning between poles). But just as recent electronics advances have made synchronous reluctance motors easier to control,

What About Reuse/Recycling?

We were originally told tired EV batteries would get a second life storing green energy or providing emergency backup power before being fully recycled. How's that going?

Nissan set up systems to assess and repackage its Leaf EV battery modules as replacement Leaf batteries, forklift batteries, and as the xStorage Home energy storage system. Similar home units reusing EV batteries are offered by Australia's Relectrify, U.K.-based Powervault, and Sweden's Box of Energy, but it's hard to determine exactly the number or percentage of retiring EV batteries reused each year.

When batteries are no longer usable, roughly 100 companies will recycle them, according to London-based Circular Energy Storage. Together they reportedly processed about half the 200,000 tons of lithium-ion batteries retired worldwide in 2019. Most are in China and Korea, near where batteries are made; the recycling rate drops to more like 5 percent in the U.S., Europe, and Australia.

Canadian firm Li-Cycle is building what would be North America's biggest battery recycling center in Rochester, New York. It's designed to process nearly 28,000 tons annually—about a third of the battery waste we'll face in 2030. Li-Cycle claims its hydrometallurgical

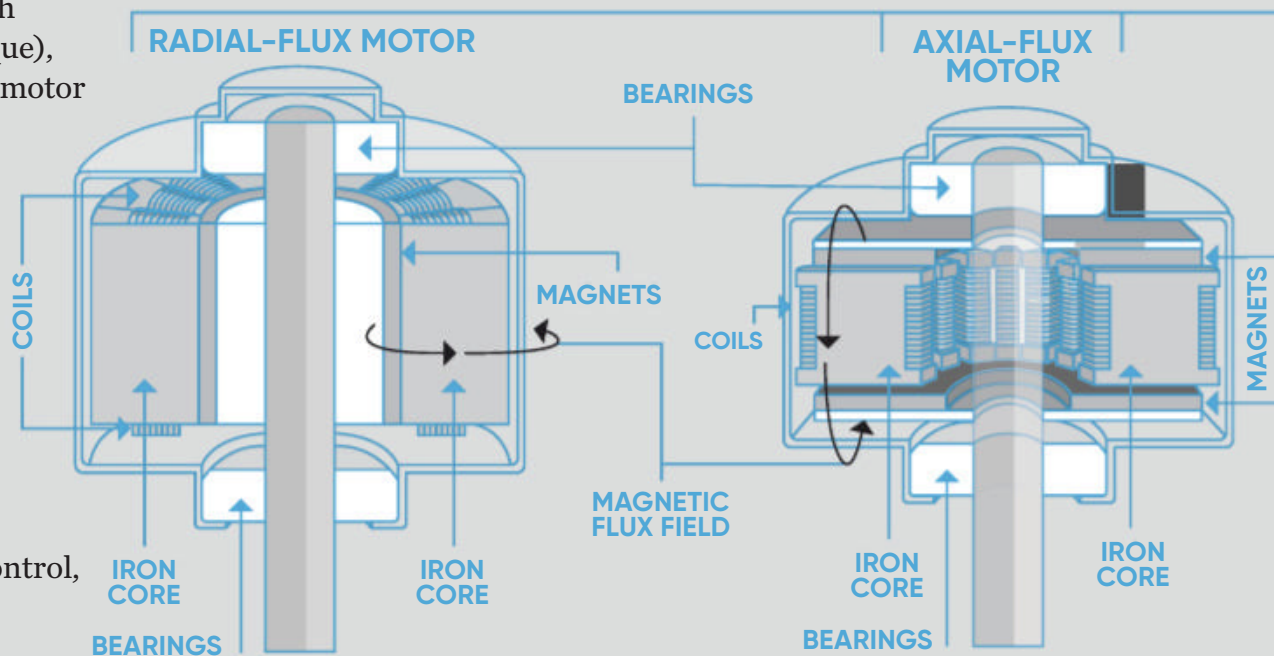
(leaching) process involves zero wastewater, minimal greenhouse gas emissions, and no landfill waste, and it recovers 95 percent of the lithium, nickel, and cobalt. This will make Li-Cycle a primary supplier of these metals and the U.S.' only domestic source of cobalt.

Redwood Materials in Carson City, Nevada, founded by Tesla co-creator J.B. Straubel, uses a combination of pyrometallurgy (thermal extraction) and hydrometallurgy processes to recycle Gigafactory-reject cells today. This recovers between 95 and 98 percent of the nickel, cobalt, copper, aluminum, and graphite and more than 80 percent of the lithium. Redwood has ambitions of also recycling general consumer electronics, and others are launching similar recycling efforts to recover rare earths and other precious elements used in EVs. One potential hitch: Cobalt is the money metal that makes recycling pay, so new battery chemistries that eliminate cobalt could set back recycling efforts.



a power-pulsing concept from Tula Technology promises to eliminate or hide this torque ripple, increasing this motor's appeal for automotive applications.

Electric motors are so efficient that most do without a traditional transmission, but a better balance of launch torque and cruising efficiency can be achieved with a second gear ratio roughly half that of the launch gear. Toronto-based supplier Inmotive's bicycle-derailleur-inspired two-speed chain-drive concept requires no high-pressure lubrication or cooling, and it suffers no frictional losses from idle gears maintaining continuous mesh. This can either stretch the range or shrink the battery by 7–15 percent. And Bosch has developed a CVT4EV push-chain transmission that offers ratio spreads of between 3.0 and 4.0, designed to provide sufficient torque from a smaller motor as speed varies. ■



GREEN CHOICES ON A BUDGET

CHEAP GREEN USED CARS

WANT TO JOIN
THE REVOLUTION
BUT NOT BREAK
THE BANK? YOU
HAVE CHOICES.

WORDS ALEX KIERSTEIN

Reduce, reuse, recycle: words to save the Earth by. But how can you apply this ethos in your driveway? The shiniest new battery electric vehicles will draw a lot of attention from your neighbors, but a humble pre-owned Toyota Prius might offset more negative consequences than plopping down cash on a new GMC Hummer EV. And not just in terms of carbon emissions, but also to your fiscal well-being.

Every new car carries a carbon and materials penalty created by its production and transport. It can take years for a green car's reduced "well to wheel" emissions to zero out that figure—not as long as the haters think, but it's a nonzero

number just the same. Many cars also lose considerable value the moment you drive off the lot. Buying used helps with both issues. Plus, in some states, you still get carpool lane access.

It's not all sunshine and carbon-absorbing roses, though. Geography greatly affects availability, battery degradation is a minor but real issue, and significant infrastructure challenges exist. Many older EVs can't handle modern fast charging, so pack a lunch. Similarly, want to refuel a Toyota Mirai with hydrogen outside of greater L.A. or San Francisco? Good luck!

But with a little forethought and some careful shopping, a used green car can reduce your impact on the climate while

saving you money in the process. We scoured national pre-owned availability and pricing using CarFax's classifieds and came up with various options, ranging from economical, practical transportation to some surprisingly fun choices. But our guiding principle here is bang for the buck.

A note: The cars listed here have battery packs, which can be fairly expensive to replace if they're damaged or degraded. A pre-purchase inspection by a dealer or specialist can help you avoid expensive issues down the road. ■

FLASHBACK: See what we said about the Honda CR-Z, way back when.



2004–2009 Toyota Prius Drive Beige to Be Green

We love brilliant engineering as much as we do horsepower. Our 2004 Car of the Year packs the former into a convenient and affordable package. **Pros** Fantastic gas mileage; cheap to buy and cheap to run; spare parts (and battery packs) galore. **Cons** It's a great hybrid but still uses gasoline; lacks modern conveniences; as fun to drive as a bag of wet gym socks.

Price Range \$3,000–\$13,000



2011–2017 Nissan Leaf EV Value Champ

The Leaf's limited range and funky looks make it a budget-friendly choice with hatchback utility and smooth, quiet driving manners. **Pros** Geek (and green) cred; cheaper to recharge than a gas station coffee; affordable EV entry point. **Cons** Robot-frog looks aren't for everyone; real-world range limits it to commuter duty; risk of costly battery pack replacement.

Price Range \$3,000–\$15,000



2011–2016 Chevrolet Volt PHEV Greening the Distance

We called our 2011 Car of the Year "a car of the future you can drive today." A decade on, that's still true—and it's a smart buy if you can find one. **Pros** Drives like an EV until gas engine needed; long overall range; it's way more fun than a Prius. **Cons** Tight rear seating; still needs gas engine maintenance; pack light because there's not much cargo room.

Price Range \$5,000–\$16,000



2013–2020 Ford Fusion Energi Conventional, Not Boring

Ford prioritized EV range and drivability for the Fusion Energi, and those are priorities we can get behind. **Pros** Convenient sedan form factor; good all-electric range; gets up and goes (for a PHEV). **Cons** Less common, more expensive than the hybrid model; when the battery is depleted, mileage is mediocre; not much junk fits in the trunk.

Price Range \$7,000–\$30,000+

UTILITY PLAYERS



2005–2012 Ford Escape Hybrid Built Ford Tough

Millions of miles of fleet duty have proven the original Escape Hybrid (and its Mercury Mariner Hybrid twin) to be rugged, reliable, and reasonably efficient. **Pros** Value factor is high; NYC taxi duty proves durability of Prius-style powertrain; reasonably efficient for an early hybrid SUV. **Cons** Many have high miles; watch out for ex-fleet and -taxi examples; wasn't all that fresh in 2005. **Price Range** \$4,000–\$13,000+



2008–2013* Cadillac Escalade/ Chevrolet Tahoe/GMC Yukon Hybrids Big Green Machines

Expensive and misunderstood when new, at used prices these big SUVs can save buyers who need full-size capability a lot at the pump. **Pros** A big, honkin' SUV for full-size lives; legit 30 percent (or more) fuel savings over nonhybrids; depreciated pricing compounds savings at the pump. **Cons** Only green compared to a nonhybrid; fuel economy still lousy; do you *really* need something this big? **Price Range** \$8,000–\$25,000

GREEN CARS THAT ARE ACTUALLY FUN



2010–2016 Honda CR-Z Hybrid CRaZy Fun

The CR-Z didn't live up to contemporary expectations, but in retrospect we can appreciate its focus on fun—and its superbly slick gearbox. **Pros** Honest-to-goodness manual transmission available; very rare breed: a fun green car; funky appeal could translate to collectibility in the future. **Cons** It's no CRX, and that is not a compliment; CVT model is a total bummer; merely a mild hybrid, which means mild efficiency bonus. **Price Range** \$5,000–\$16,000



2018–2020 Mitsubishi Outlander PHEV So Long as You Love Me

You would think there would be more plug-in hybrid SUVs, and there will be. But if you want a used one, this is your best bet. **Pros** Only used compact PHEV SUV; solid numbers: 22 miles of EV range, 74 mpg-e; has enough space to do SUV things. **Cons** Disappointingly dated interior; oldest models are still relatively new and expensive; not that efficient when the battery is depleted. **Price Range** \$17,000–\$30,000



2013–2017 Ford C-Max Energi PHEV Not a Penalty Box

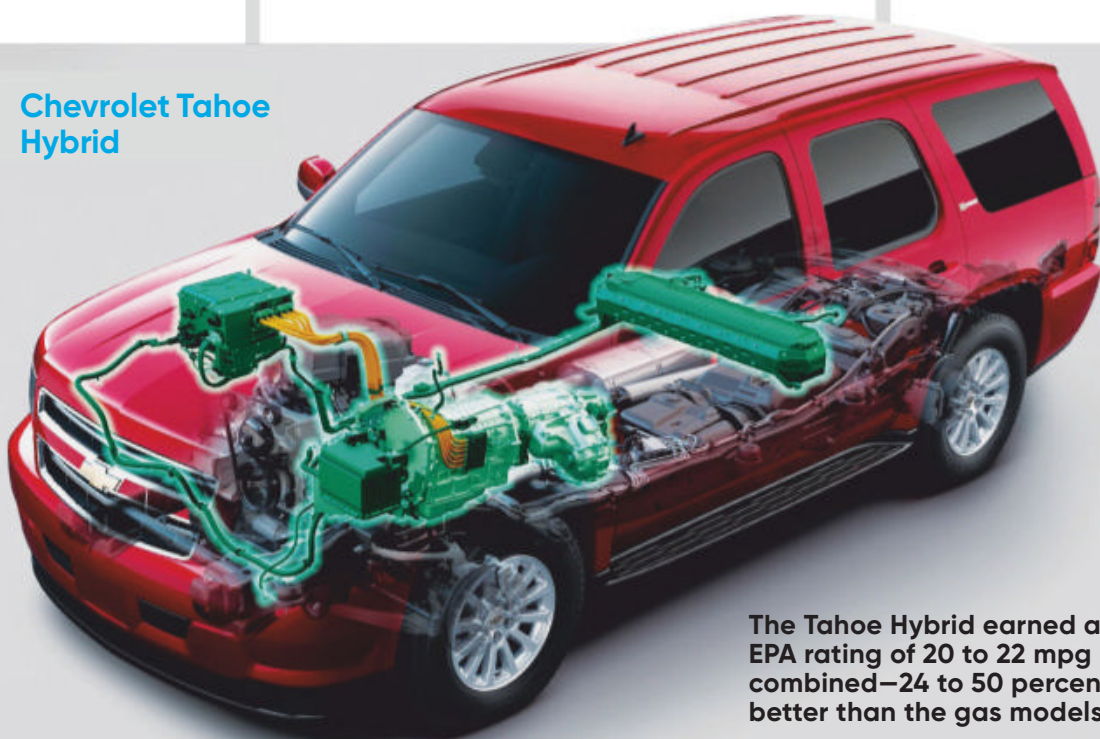
Ford's first PHEV has a lot to offer, with a great combination of driving manners, utility, and EV-only range at attractive prices. **Pros** Surprisingly fun to drive; great utility and all-around visibility; 20 miles of electric-only range. **Cons** Relatively poor fuel economy when battery depleted; less cargo room than regular hybrid version; looks like an abnormally swollen hatchback. **Price Range** \$5,000–\$20,000



2017–2019 Volkswagen E-Golf The Golf of EVs

It has almost everything we like about the Golf baked into one green package, and you don't have to be a die-hard EV nerd to understand its appeal. **Pros** Looks, feels like a Golf; 2017+ models have decent 125-mile EPA range; few typical EV driving quirks. **Cons** Less range than contemporary alternatives; 0–60 time of 9+ seconds, so fun-ish; Eco mode saps all the fun. **Price Range** \$13,000–\$25,000

Chevrolet Tahoe Hybrid



The Tahoe Hybrid earned an EPA rating of 20 to 22 mpg combined—24 to 50 percent better than the gas models.



2017–2020 Chevrolet Bolt EV A Long-Range EV on a Budget

Our 2017 Car of the Year is the first mass-market EV to come close to the sweet spot of price and range. Used ones offer even more return on investment. **Pros** Spacious and thoughtfully practical; 238 miles of real-world range; drives like a hot hatch. **Cons** Be sure it's had its battery recall handled; goofy styling; old Bolts can't abide fast charging. **Price Range** \$12,000–\$35,000

*Cadillac Escalade Hybrid availability started with the 2009 model year.

TRANSFORMERS

CONVERTING OLD CARS TO EVS IS NO LONGER A NICHE INDUSTRY

If you think the electrification wave is limited to mainstream automakers, wait until lawmakers run out of new internal combustion engines to tax. We're not saying gasoline-burning classic cars will be banished, but there's no guarantee they won't gradually become tougher and tougher to own and operate. Converting a classic car to battery electric power is already a thing, whether inspired by prescience or mechanical frustration. Want to breathe modern life into your baby? Here's a selection of some of the biggest names in the EV conversion biz.



Chevrolet eCrate (chevrolet.com/performance-parts/electrification)

You might need to get used to saying "crate motor" instead of "crate engine." Chevrolet unveiled plans for a range of electric crate motors and batteries for hobbyists, cleverly called "eCrate," falling right in line with GM's ongoing push toward an all-electric future. The first available motor and battery combo comes straight from the Bolt; a 60-kWh battery feeds the motor, sending 200 hp and 266 lb-ft through a four-speed automatic.



Not enough oomph? Chevrolet confirmed GM's potent new Ultium battery packs will eventually join the eCrate lineup. Pricing and availability are still TBD, however, so you have time to decide.



EV West (evwest.com/catalog)

Most people don't have six-figure budgets to gift their old cars electric powertrain transplants; California-based EV West is a one-stop shop for zappy conversion projects. Aside from handling full builds for customers at its workshop, EV West's extensive online catalog of both vehicle-specific kits and individual parts is comprehensive enough to jump-start just about any homebrew build. Thumbing through the array of available DC converters, motors, chargers, controllers, and hot-rod Tesla parts is enough to send anybody to the cheap car section of Craigslist for their next project. Pricing for EV West's in-house conversions depends on the project, so call the company before you move money around.

Lunaz (lunaz.design)

In sharp contrast to the many EV conversions performed on vintage 4x4s or smallish sports cars, U.K.-based Lunaz focuses on a series of impeccably engineered electrified British classics. Lunaz's electric Jaguar XK120 and Range Rover Classic are a treat, but we have big eyes for its stunning, eco-friendly 1961 Rolls-Royce Phantom V. Aside from a 120-kWh battery and a claimed 300 miles of range, the fully restored Rolls carries a host of tastefully hidden modern touches like device charging ports, an infotainment system, and onboard Wi-Fi. All yours for about \$700,000.



Garage Italia (garage-italia.com)

For the smaller, chicer sort of guilt-free classic fun, the design-obsessed craftspeople at Garage Italia electrified a set of vintage Fiat 500 Jolly "Spiaggina." You might want to bring sunblock; the Spiaggina's cruising range of around 75 miles and a top speed of just 53 mph means it's best kept within the confines of the Amalfi Coast. If the \$60,000 sticker is a bit too dear for a beachside toy, hit up Hertz's Selezione Italia collection the next time you're in Italy, where you can rent one for about \$365 a day.





Moment Motors (momentmotors.com)

Got a hankering to kick the oil habit with something classic in the heart of Texas? Austin-based Moment Motors and its staff are your new best friends. Moment Motors works exclusively on classic stuff, so bring it your shiniest BMW 2002, Triumph TR6, or Datsun 240Z. Heck, roll up in whatever old car you want; Moment's modular motor system is adaptable to fit in essentially anything, even replica Shelby Cobras. These are high-quality conversions, so expect to pay between \$50,000 and \$150,000 for a complete project.



Zero Labs (zerolabs.com)

Get in touch with Zero Labs if you're after something plug and play. The high-end California-based workshop revealed a new modular "not-a-skateboard" skateboard EV platform designed to fit a wide range of popular classics, including Ford Broncos and F-100s, Toyota FJs, Land Rover Defenders, muscle cars, and even smaller sports cars. Aside from the available 600-hp dual-motor setup and claimed 235-mile range from a 100-kWh battery, each platform boasts 50/50 weight distribution and rolls on an independent Fox suspension. You don't even have to clear out home garage space; Zero Labs will do the conversion for you at its facility as part of the cost, which should be revealed later this year.



Stealth EV (stealthev.com)

Is a big-money, ground-up EV build what you need? Call Stealth EV. This is another one of those do-everything shops: Aside from full in-house conversions, Stealth EV offers professional engineering consultation, custom parts development, and project planning. Provided you have the budget, it seems Stealth is down for any challenge. Look for its handiwork under the hood of Icon 4x4's EV builds and in creations from Zelectric (see below). Pricing for Stealth EV's conversions are based on the car and level of build, so reach out with your ideas.



Zelectric (zelectricmotors.com)

Sorry, but if you want Zelectric's high-voltage artisans to convert anything other than an original air-cooled Volkswagen or early Porsche, keep driving—any other gas guzzler will be turned away. If you happen to bring a well-kept VeeDub, you'll drive out in one of the most comprehensive and well-engineered EV conversions on this list. With 100 miles of range from the Tesla-sourced battery pack and a top speed exceeding 100 mph, a Zelectric VW is a silent cruise missile compared to a VW with the original pancake engine. The best bit? The cars retain their original manual transmissions, and the process is reversible. Prices for Zelectric-fying a Beetle or Karmann-Ghia start at \$68,000 and climb to \$78,000 and \$88,000 for the VW Bus and Porsche 911/912, respectively.



HIT THE QR CODE
to see the new definition
of "crate motor." No, it
ain't a small-block.

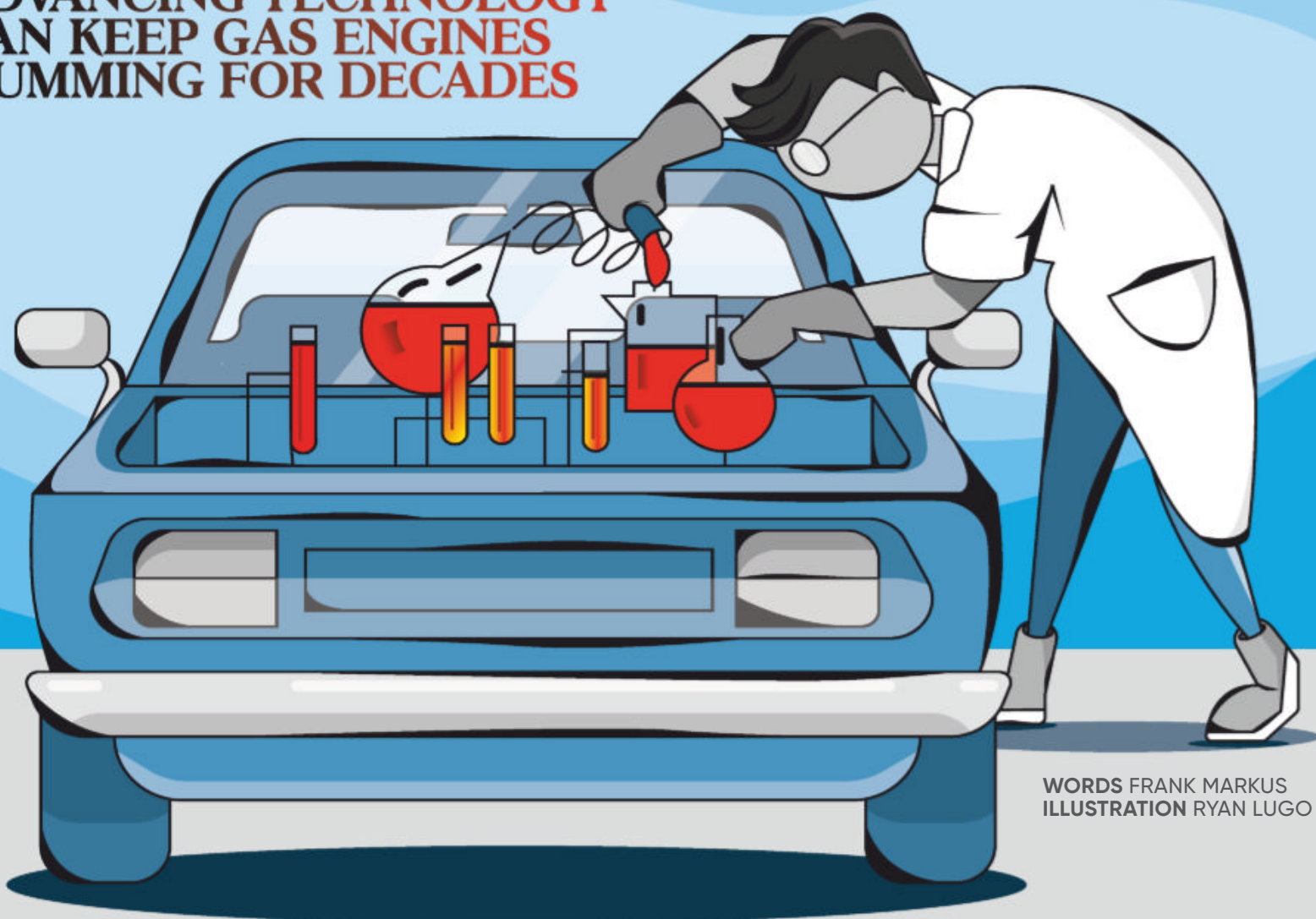


Totem Automobili (totemautomobili.com)

Labeling this a "conversion" is a gross understatement, but we'd be remiss to not mention Totem Automobili's wild carbon-bodied Alfa Romeo Giulia GTA. Although it starts life as a 1960s Alfa, only 10 percent of the original chassis is retained for the so-called GT Electric, reinforced and redesigned with top-shelf, cutting-edge hardware. A 50.4-kWh battery and rear-mounted electric motor return an estimated 222 miles of range and a whopping 518 hp and 692 lb-ft, hustling the 3,100-pound coupe from 0 to 60 mph in a claimed 3.4 seconds. The Singer-esque interior is just as jaw-dropping—as it should be, with a price tag of about \$500,000.

A Green Combustion Future?

ADVANCING TECHNOLOGY
CAN KEEP GAS ENGINES
HUMMING FOR DECADES



WORDS FRANK MARKUS
ILLUSTRATION RYAN LUGO

Combustion engines won't vanish completely any time soon, if ever. Certain transportation tasks or operating environments simply don't lend themselves to battery- or hydrogen-powered electric propulsion. A century and a half of research and development has greatly increased the efficiency of combustion engines, and engineers have loads of additional tricks up their sleeves that promise to extract even more work from a molecule of fuel while producing even fewer harmful emissions. Here are but a few we're keeping our eyes on, listed in order of complexity and cost to implement.

A 98-Octane Fuel Standard

Simply being able to design an engine to run 15:1 or higher compression greatly improves its thermodynamic efficiency and power density, permitting further engine downsizing. That requires higher-octane fuel, and a research-octane number (RON) of 98 represents a sweet spot, above which producing/refining the fuel consumes more energy, decreasing the well-to-wheels energy/CO₂ benefit.

Smart Cylinder Deactivation

Engines are sized for worst-case scenarios like quarter-mile acceleration or towing heavy trailers up Davis Dam. Cylinder deactivation improves efficiency during less extreme driving situations by making a few cylinders work

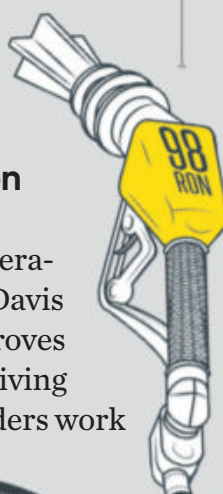
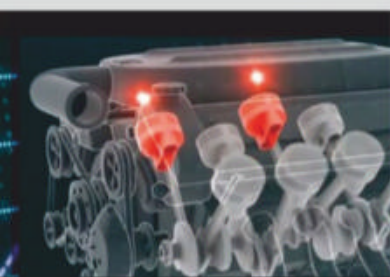
Davis Dam hard while the others do nothing. Dynamic Fuel Management can shut off any or all cylinders in GM's 5.3- and 6.2-liter V-8s to boost EPA fuel economy by nearly 12 percent. Tula Technology and Eaton now propose similar systems for long-haul diesel engines, where a smaller fuel efficiency payoff (1.5–4.0 percent) pays huge NO_x dividends by maintaining exhaust temperatures needed to keep catalysts lit.

Fancy Ignition Systems

Because fuel takes time to burn, conventional spark plugs fire as the piston is still moving upward, rendering the initial combustion counterproductive. Schemes to ignite more of the mixture simultaneously promise faster combustion that allows it to mostly happen on the downstroke. Ford developed near-infrared lasers to ignite multiple points in a combustion chamber, but cost and reliability remain problematic. Transient Plasma's drop-in spark plug replacement injects sheets of low-temperature plasma that promises to ignite ultra-lean mixtures quickly and coolly for a fuel economy boost of 10–15 percent and dramatically reduced NO_x. Even Maserati's new pre-chamber Twin-Combustion system qualifies as an ignition accelerator.

Innovative Blowers

An engine's power is limited by the amount of air it can ingest, which is why crankshaft-powered superchargers and exhaust-powered turbochargers were developed more



than a century ago. Electric superchargers using recovered energy power the Volvo Drive E and Mercedes M256 engines, among others; adding a motor/generator to a turbocharger eliminates lag under power and permits energy harvesting while cruising. Two interesting riffs on crank-powered superchargers are the Torotrak V-Charge centrifugal blower, which employs a CVT to quickly match speed to demand, and Hansen Engine Corp's Lysholm-type blower, which features a window that opens or closes to match demand for air pressure while minimizing losses to deliver turbo efficiency with supercharger responsiveness.

Variable Compression Ratio

This cake-and-eat-it-too concept promises high compression for parsimonious light-throttle cruising and low compression when the turbo is on boost. Nissan's Rube-Goldberg compound connecting-rod gizmo varies the engine's stroke, altering compression infinitely between 8:1 and 14:1. We've been underwhelmed by the Nissan/Infiniti VC-Turbo's performance and fuel economy, and we wonder if FEV's eccentric connecting rod might be simpler and work better. Oil pressure delivered via the crankshaft rotates an eccentric bearing in the piston end, changing the stroke across a narrower range, say from 8:1 to 12:1, promising a 5 percent drop in fuel consumption.

Homogeneous Charge Compression Ignition

Efficiency of a diesel with gasoline emissions! That's the dichotomous promise of HCCI, which seeks to spontaneously ignite lean gasoline mixtures by compression. GM, Mercedes, and Hyundai all had promising HCCI programs, but only Mazda has brought HCCI to production. Sort of. SkyactivX uses a spark plug some of the time and is still deemed too costly for sale in North America. Nautilus Engineering has proposed an HCCI concept that involves a small piston atop the main piston that enters its own small, higher-compression cylinder at the top of the stroke to initiate compression ignition. However, we're unaware of any OEM contracts the company holds.

Waste Energy Recovery Systems

Combustion engines make a lot of heat and vibration; why not use it to generate steam power or thermoelectric or piezoelectric energy? BMW's proposed Turbosteamer system and numerous others have been abandoned for cost and weight reasons. Solid-state thermoelectric generators promise to turn heat, typically from exhaust components, directly into electricity. (Production feasibility awaits improvements in the efficiency of the requisite materials from today's roughly 5 percent level.) And Duke University researchers propose using piezoelectric crystals like those that expand with voltage to actuate direct fuel injectors to generate power under vibration.

Completely New Engine Concepts

Any radically new engine design faces immense industrial inertia. Nevertheless, a few "better mouse-traps" seem to be holding their own. Achates Power recently received another \$5 million grant from the Army to continue developing its three-cylinder, six-opposed-piston, twin-crankshaft, two-stroke engine. In a 4.9-liter super- and turbocharged prototype producing 275 hp and 811 lb-ft, its efficiency reportedly outperformed a 6.7-liter Power Stroke turbodiesel in a Ford F-Series by 20



"Inside-out" Wankel engine concept.

Green Fuels Promise Carbon-Neutral Combustion Now

BIOFUELS: Using green energy to make fuel from plants that pulled CO₂ out of the atmosphere theoretically adds no new CO₂ to our "greenhouse." But running on pure ethanol made from corn doesn't usually count, because the land used to grow that corn has typically been converting the same amount of CO₂ whether it became fuel or corn syrup, resulting in no net carbon reduction. Biofuels made from cellulosic feed stocks like corn stalks, miscanthus grass, or new crops planted where nothing has been or could be grown before do count, and there are numerous processes for converting cellulosic materials or even trash to ethanol, methanol, or butanol. There are also several algae-to-biodiesel processes identified.

Sadly, they're all too costly to compete with cheap gasoline.

Direct Carbon Capture:

Several schemes have been proposed to pull CO₂ out of the air and hydrogenate it to form a hydrocarbon fuel. Prometheus Fuels plans to make gasoline from CO₂, and an Audi/Sunfire collaboration intends to make diesel from "blue crude" created by using green electricity to combine carbon from CO₂ with hydrogen from water. Carbon Engineering in British Columbia, Canada, plans commercial-scale production by 2022. And ReactWell hopes to combine an Oak Ridge National Laboratory process for converting CO₂ to ethanol with its own process for upconverting that to bio-crude oil that's refinable into various hydrocarbon fuels.



ILLUSTRATION: GLENN LUMSDEN

percent. Scuderi and Primavis have proposed split-cycle engines that execute the intake/compression and combustion/exhaust cycles in separate cylinders, each designed for their disparate tasks. This keeps temperatures down. Scuderi ran into legal trouble with its investors, Primavis envisioned its tiny two-stroke engine primarily as a range extender, and neither has made much news lately, though their underlying science seems sound. The LiquidPiston X-1 concept is an "inside-out Wankel" rotary engine featuring a rotor shaped like the Wankel's housing wobbling through a vaguely triangular housing with three combustion chambers. Mounting oil seals on the stationary housing makes

them easier to lubricate. It's still in active development as a range extender. And then there are bigger leaps of design, like Astron Aerospace's rotary internal combustion turbine concept, which combines split-cycle operation, HCCI, a superlong expansion cycle, and other great ideas. It's also still in active development, generating impressive power, torque, and efficiency claims. ■

DAYS OF POWER PAST

WORDS AARON GOLD
PHOTOGRAPHY BRANDON LIM

THE GASOLINE
VS. ELECTRIC
DEBATE IS
MORE THAN
100 YEARS OLD



Gasoline or electric? For the first time in more than a century, both are viable options, but what was the decision like 100 years ago? With the help of the Henry Ford museum in Michigan, we traveled back in time to pit a Ford Model T against a Detroit Electric Model 90.

Both cars were mature products. Ford had made few changes to the T since its 1908 introduction, and in 1921 it was approaching the peak of its popularity. Likewise, the Anderson Electric Car Company had kept its Detroit Electrics more or less the same since 1914, when sales of electric cars rivaled those of gasoline-powered ones, thanks to high fuel prices during World War I. By the time our test car was built in 1922, though, electric car sales were in decline.

Posh Detroit Electric vs. Spartan Ford

Then as now, electric cars were expensive to build, so the Detroit Electric was positioned as a luxury car. The Model 90's cabin is outfitted like an Edwardian sitting room, with plush carpet, drapes, flower vases, and what appears to be a well-stuffed love seat. That's the perch for the driver and her companion. (Electric cars were marketed to women; Clara Ford, Henry's wife, was one of Detroit Electric's most prominent customers.)

A cushy bucket seat up front swivels toward the back seat for socializing, and a small, padded stool offers space for a fourth occupant. Eight giant windows—with curved glass in the corners, a novelty at the time—let in all the sunlight you can ask for. The two-tone paint finish looks deep enough to dive into.

The Ford feels as stingy as the Detroit is posh. Its seats are simple affairs upholstered in a cloth-based imitation leather, and the wooden floor is covered with a rubber mat—waterproof, we assume, since our test car has a folding top but no side windows. There's also no driver's door because you don't need one. Only rear passengers are allowed the extravagance of getting in and out of the car on whichever side they please. As for the paint, you don't have to ask—it's the same color as the other 971,609 Model T's Ford built that year.

The cars' prices reflect their relative luxury: By 1921, Henry Ford whittled the Model T's base price to \$370 (about \$5,100 adjusted for inflation), and a touring car like the one we have here started at \$415 (\$5,714). The Detroit Electric's base price in 1922 was \$2,985 (that's \$46,203 today), and our test car listed closer to \$4,000—almost \$62,000 in today's dollars.

Getting Started and Driving

Driving the Model T helps you understand the Detroit Electric's appeal. Our T is equipped with an electric starter, then only in its third year as an option; as with many things, Ford was slow to adopt such modern technology. Our test T is one of



the cars used today to give rides around Ford's Greenfield Village, where even older T's have been fitted with electric starters for safety; hand-cranking a car is dangerous, and if not done carefully—and sometimes even if done carefully—it can result in broken bones.

Not that electric starting the T is turnkey easy. If the car is cold, first tug on the priming lever next to the radiator to set the choke. Pull the handbrake lever as far back as it will go, and make sure the ignition timing lever—that's the left-hand one on the steering column—is all the way up to the fully retarded position. Pull the right-hand lever, the throttle, down to the fifth or sixth notch, and turn the ignition switch to "Battery." If the engine is warm and the ignition timing is advanced slightly, the engine might fire on its own at this point. Assuming it doesn't, step on the starter button, and the engine should start. Turn the ignition switch to "Magneto," and you're ready to move.

If you hand-crank your Model T, set the handbrake and throttle as above. The owner's manual recommends advancing the timing three or four notches, though this increases risk of kick-back and personal injury. If the engine is cold, prime it with the ignition off by pulling the priming lever while giving the engine a couple of half-turns with the starting crank. Turn the ignition switch to "Magneto," then engage the crank at about the 9 o'clock position.

You drive the Detroit Electric from this plush sofa. The front seat swivels for socializing.

The Detroit Electric 90 (left) looked the part of a town car for well-to-do ladies, while the Model T (right) was far more quotidian.





**Detroit Electric
Model 90**



Cranking should be done with the left hand, palm up and open, so that if the engine kicks back, the lever won't yank your arm down and dislocate your shoulder. You'll also want to keep your face and right shoulder clear to avoid possible broken bones. Pull up sharply, and with a couple of good yanks the engine should start.

Starting the Detroit Electric is quite a bit simpler: Turn a switch.

Getting down the road is also a lot more straightforward. Once you settle into your couch, fold two levers down from the door pillar. One is the accelerator,

which has a neutral position and four power notches; the steering tiller is the other. Stepping on a pedal at the base of the driver's seat engages reverse, and a double pedal sprouting from the floor applies and latches on the brakes.

Mechanically, the Detroit Electric is as simple as you would expect: The accelerator is linked to a drum controller with copper contacts that sits under the driver's seat. Batteries are located in the boxes fore and aft of the cabin. Originally, it was equipped with Edison nickel-iron batteries that provided an advertised range of 80 miles. The electric motor is slung under the frame and directly drives the differential on the rear axle. The mechanical brakes act on the rear wheels only, and the whole shooting match rides on solid axles suspended by leaf springs.

The Model T has a similar chassis setup, but similarities end there. The engine is a model of engineering simplicity: A 2.9-liter side-valve flathead I-4 doesn't even have a water pump, relying instead on convection to circulate its cooling water. A

single-barrel updraft carburetor supplies fuel, while a flywheel-mounted magneto provides power for the spark. Instead of a distributor, it uses four trembler coils; unlike modern ignition systems, they produce a constant spark as long as they're engaged by the timer. This is why a worn Model T engine that's recently stopped with a piston just past top dead center, trapping some residual air/fuel mixture, will sometimes start without cranking. Output is 20 hp at 1,600 rpm, and torque is a surprisingly strong 83 lb-ft at a mere 900 rpm. The two-speed transmission uses a "constant-mesh" planetary gear setup like those used in modern-day automatics—except there's nothing automatic about it.

The Model T has three pedals, but they don't do what a modern driver expects. Here's your basic Model T driving primer: Put your left foot on the left pedal, which controls the bands that engage low and high range gears; it's held in its center (neutral) position by the handbrake lever. Use your right foot to step on the right pedal, which applies the transmission brake. Now squeeze the handbrake lever's handle and push it all the way forward, which releases the wheel brakes and the high-range lockout (the gizmo holding the left pedal in the neutral position). Give the car a little gas by pulling down on the throttle lever. Take your right foot off the brake and push the left pedal all the way to the floor to engage low gear. Off you go!

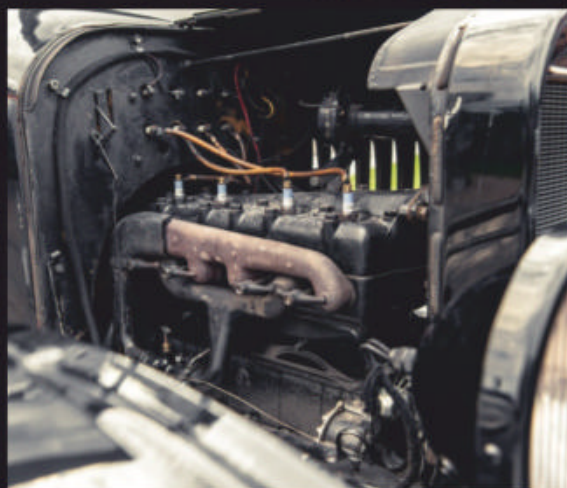
Once you get moving, it's best to shift right into high range. This takes practice to do smoothly; basically, you want to drop the throttle to idle as you lift your foot all the way off the left pedal, which—with the handbrake lever all the way back—is now free to move to the uppermost position that engages high gear. Move the pedal quickly into neutral and slowly into high; once the shift is made, you can drive with the hand throttle. The T's engine doesn't mind being lugged, and you can slow down enough to take corners (preferably at a walking pace) without downshifting.

The under-seat drum controller is the simple mechanism that regulates the Detroit Electric Model 90's speed.





1921 Ford Model T Touring



To stop, push the left pedal to its center position, step on the right pedal, and hope you have enough room. For a panic stop, you can close the throttle and downshift to low as you brake; just be sure to get into neutral as the car stops so it won't stall. In a pinch, you can pull on the handbrake to engage the rear brakes. To back up, stop the car, hold the left pedal in the center position, and push the center pedal to the floor. Easy, right?

The Detroit Electric gets away quickly if you pull the tiller back to the fourth notch, though the museum staff is gentler with this artifact. As with a modern EV, power is smooth, even, and, apart from a slight growling from the gears, silent.

The Model T is louder than expected and vibrates like crazy. It has plenty of low-end torque, and you can get away quickly if you leave it in low range and race the engine. Forty mph is possible, but it's a handful at even half that speed, thanks to fast and loose steering, excessive body lean even at a parking lot pace, and freight train stopping distances. Driving fast is not for the faint of heart or the weak of bladder.

The Detroit Electric tops out at a more sedate 25 mph, plenty adequate in its day, as contemporary speed limits (when they existed) were generally 10 mph in town and 15 mph on rural roads. Although steering with the tiller takes getting used

SPECS	1921 Ford Model T Touring	1922 Detroit Electric Model 90
BASE PRICE	\$415 (\$5,714 in 2021 dollars)	\$2,985 (\$46,203 in 2021 dollars)
VEHICLE LAYOUT	Front-engine, RWD, 5-pass, 3-door convertible	Mid-motor, RWD, 4-pass, 2-door coupe
ENGINE/MOTOR	2.9L/20-hp/83-lb-ft side-valve 8-valve I-4	10-hp/20-lb-ft (est) DC series-wound electric motor plus 24.3-kWh Edison NiFe battery
TRANSMISSION	2-speed planetary manual	1-speed auto
CURB WEIGHT	1,700 lb (est)	3,600 lb (est)
WHEELBASE	100.5 in	100.0 in
L X W X H	134.5 x 68.0 x 83.0 in	159.0 x 65.0 x 71.0 in
0-60 MPH	N/A (top speed: 45 mph)	N/A (top speed: 25 mph)
FUEL ECON	13-21 mpg (mfr est)	100-141 mpg-e (est, 70-100 mile range)



to, the quiet sitting-room surroundings isolate you from the outside world and make driving a more relaxing experience.

Picking a Winner in the 1920s

A hundred years ago, range and infrastructure were the primary challenges facing electric cars. The infrastructure issue wasn't merely a lack of chargers, but rather a lack of electricity. Most big cities were wired, but rural electrification was still far in the future—when our Model 90 was built, the Tennessee Valley Authority didn't yet exist, and the Rural Electrification Administration wouldn't be formed for nearly 15 years. Gasoline, steam, and horsepower (the warm-blooded kind) were the only viable alternatives.

Electric cars remained popular with doctors, who needed fast, reliable starting, and well-to-do urban women, who preferred the electric's clean, odor-free operation. Even so, Charles Kettering's electric starter of 1912 put the electric car's (temporary) end within sight. Electrification, when it came, spread rapidly, but Americans chose gas for their cars.

Picking a Winner in the 2020s

Just like modern electric cars, it's hard not to like the Detroit Electric once you experience it. The comfortable cabin, quiet ride, and simple controls make it a breeze to drive, and it's easy to pity the Model T driver with their arms, hands, and legs in constant motion, exposed to the elements with ears ringing and nostrils stinging.

But there's something enchanting about the Model T, which removes nearly all barriers between organism and mechanism. Driving the T is a lot of work, but it's also machine-made magic, something you just don't get in the Detroit Electric. The Model T was designed to go anywhere, and once familiar with its controls, you feel like anywhere is possible, with only a couple of wrenches and a few obliging fuel stations along the way. The Model 90 is the better car, but today the Model T is the more compelling antique. ■



BMW 228i

BMW X7



Updates on our long-term fleet

MT GARAGE

PHOTOGRAPHY MT STAFF



Arrival: 2021 Honda Odyssey (EX-L)



EPA City/Hwy/Comb Fuel Econ
19/28/22 mpg

"We've had a baby boom at *MotorTrend*, so staffers will be testing the Odyssey in ways we haven't been able to in the past."

Ed Loh

Base Price \$39,635 As Tested \$39,635

Dear Honda Manufacturing of Alabama employees,

Just a quick note to let you know your 2021 Honda Odyssey EX-L (VIN ending in 7577) has arrived safe and sound, thanks to your colleagues at America Honda Motor Co. and the folks at Scott Robinson Honda in Torrance, California.

Thanks for painting it in such a lovely shade of Obsidian Blue Pearl; the dark blue really helps the new chrome strip above the redesigned headlights pop and looks stunning against the gray "-L for leather" interior. You might be curious why we picked the Odyssey in the EX-L trim level, versus the fancier Touring or Elite models you build.

Well, when testing vehicles, especially over longer time periods, we try to ensure they best represent what a large percentage of the American population drives. As you know, minivan sales have taken a dive in recent years following the rise of SUVs and CUVs; you've added the two-row Passport to your manufacturing lines out there in Lincoln.

Still, according to your colleagues in PR, the Odyssey has been the No. 1 retail minivan nameplate in America for the past 10 years, and it captures more than 40 percent of all retail minivan sales. We checked, and both claims seem accurate when you key in on the word "retail," as other minivans have sold more units from time to time, but only if

you include fleet sales. As for the midlevel EX-L trim, per your spokesperson, it's "by far the most popular, representing almost 40 percent of sales." This we can't confirm but have no reason to dispute.

We also can't dispute the options, because VIN 7577 came with none. We're not complaining; after reviewing the long list of standard features that come with the as-tested price of \$39,635, we're quite satisfied with all the comfort and convenience amenities, including Apple CarPlay and Android Auto, the dual power-sliding doors, power tailgate, and heated, adjustable front seats (12-way

for driver, eight-way for front passenger).

We've had a bit of a baby boom at *MotorTrend*, so several staffers and their families will be testing the Odyssey in ways we haven't been able to in the past; the multiple seating configurations and LATCH system for securing child seats should get a workout, and we'll definitely explore the limits of your stain-resistant surfaces. We would have liked to try the onboard vacuum, but its availability is on hiatus.

We're also interested in exploring the newly updated Honda Sensing suite of safety and driver assistance features, which is now standard on all

SPECS VEHICLE LAYOUT Front-engine, FWD, 8-pass, 4-door van
ENGINE 3.5L/280-hp/262-lb-ft SOHC 24-valve V-6
TRANSMISSION 10-speed automatic **CURB WEIGHT (F/R DIST)** 4,515 lb (55/45%) **0-60 MPH** 6.7 sec **QUARTER MILE** 15.1 sec @ 94.4 mph
BRAKING, 60-0 MPH 119 ft **LATERAL ACCELERATION** 0.75 g (avg)
MT FIGURE EIGHT 28.9 sec @ 0.57 g (avg) **ENERGY CONS, CITY/HWY** 177/120 kWh/100 miles **CO2 EMISSIONS, COMB** 0.87 lb/mile



UPDATE HONDA CIVIC SI	ARRIVAL HONDA ODYSSEY	HYUNDAI SONATA	UPDATE KIA SOUL	KIA TELLURIDE	VERDICT MAZDA 3	UPDATE MAZDA CX-30
						
						
MERCEDES-BENZ GLE 450	NISSAN SENTRA UPDATE	RAM 2500 HD UPDATE	SUBARU OUTBACK	TOYOTA GR SUPRA	TOYOTA VENZA	VOLVO XC40



Its color scheme may say, *Children of Men*, but our Odyssey's cabin is actually a pretty great place to be.



Odyssey trims, but hopefully we don't test the system to its fullest extent. We've had good experiences with Honda's adaptive cruise control and lane keep systems, but many other automakers have made progress in this space.

Despite all the supercars and hot metal we profile online and put on our covers, please know that our staff really digs minivans. Your Odyssey came

to us with only 30 miles on the odometer, and even though we're challenged like a lot of Americans with ongoing closures of business and travel destinations and staying at home in general, we've already amassed more than 3,000 miles. More on how that happened in coming updates. Watch this space as we begin our odyssey in your Odyssey.

Sincerely, *MotorTrend*



2020 Kia Soul



Service Life: 13 mo/15,721 mi
Average Fuel Econ: 26.5 mpg

"We finally dissect what happens when you push the Soul to its limits." Brian Vance

Avg CO2 0.73 lb/mi **Energy Cons** 125 kWh/100 mi **Unresolved Problems** None **Maintenance Cost** \$39.95 (oil change, inspection, tire rotation) **Normal Wear** \$0 **Base Price** \$23,685 **As Tested** \$25,755 **EPA City/Hwy/Comb Fuel Econ** 27/33/30 mpg **Real MPG** 23.5/36.2/27.9 mpg

Spend enough time driving any vehicle, and you get a good, solid perspective of its capabilities. Yet there is no substitute for proper test track data to help understand a car's real competency. So we sent the Soul off in the hands of our reputable test team to sort out its aptitude in the controlled and extreme parameters the test track offers.

Acceleration notes from chief test driver Chris Walton describe how the Soul does not respond well to aggressive pedal overlap (aka brake standing) but does best with a small dose of it. Walton describes difficulty getting the Soul to repeat the same run, and thus the results varied each time. He also describes a CVT that, regardless of the mode selected, always produced unwanted rev drops during hard acceleration.

All of that aside, the Soul EX hit 60 mph in 8.6 seconds with an elapsed quarter-mile time of 16.7 seconds. Although that isn't exactly quick, it easily leaves behind the Nissan Kicks and

Toyota's C-HR each by more than a second and a half. Yet the Soul loses to its mechanical cousin, the Kia Seltos S, which Walton squeezed for an 8.3-second run last summer. (Stay tuned for more about the Seltos in the coming months, as we've added one to our long-term fleet.)

Our braking test from 60 mph resulted in a generous nose dive, rear-end hike, and a bit of shaking in the steering wheel, but nonetheless the stop from 60 mph was a relatively short 116 feet.

In the figure-eight test, our test driver noted plenty of pitching and diving, as well as disappointingly uncontrolled body motions. Also noted was the oversensitivity of the brakes, which didn't like quick applications followed by a slow release. This meant the brakes had to be released earlier to prevent them from interfering with turn-in. Moderate understeer was noted. The Soul's figure-eight lap time was 27.4 seconds, again beating the C-HR and Kicks, along with a front-drive Seltos and Hyundai Venue.

These instrumented numbers reinforce something we've known about the Soul throughout its time here: It's not a car you'd buy for dynamics, but its real-world competence is better than some competitors.



2020 Ram 2500 HD



Service Life: 5 mo/13,583 miles
Average Fuel Econ: 13.3 mpg

"Short visits with other Rams are enjoyable, but we're glad to come home to ours when it's time for a long trip or heavy task." Frank Markus

Avg CO2 1.67 lb/mi **Energy Cons** 290 kWh/100 mi
Unresolved Problems None **Maintenance Cost** \$0
Normal Wear \$0 **Base Price** \$54,045 **As Tested** \$76,130 **EPA City/Hwy/Comb Fuel Econ** Not rated

I recently got a chance to spend a week each in two Rams, which gave me a chance to try some options unavailable or opted against when we configured Guffman. One was a Ram 2500 Power Wagon that let me try out the front bench seat, the whopper 12.0-inch vertical infotainment screen, the RamBox bed, and the gas V-8 (our Cummins diesel I-6 is too big and heavy to work with the PW's winch and suspension)—not to mention the winch and diff locks. Then I spent a week in a Ram 1500 EcoDiesel to compare the junior oil burner's drivability.

The Power Wagon's 40/20/40 front bench features a backrest that folds down to form an armrest with three cupholders. Opening its lid reveals a change dispenser, a USB port, and a 10-by-8-by-3-inch stowage bin. Underneath the seat cushion is a bigger storage bin. A floor-mounted bin next to the transfer-case shifter could hold a phone or pens and pencils. The bench seat makes sense in the Power Wagon, as that floor shifter precludes Guffman's awesome center console, but we live out of that console on trips, and we've never missed a sixth seat belt.

Guffman's transfer case is push-button operated, but the PW replaces those buttons with axle-locking and stabilizer-disconnect buttons, plus a rotary shift knob that replaces the column shifter our Aisin automatic requires. The four USB jacks and AC plug are located down near where the center stack meets the floor, along with a shallow bin and another coin dispenser.

We saved \$1,995 by not getting the 12.0-inch vertical screen. I thought I'd miss it, but I never found a must-have combination of Apple CarPlay on one half of the screen and something else



on the other. Settings are a bit easier to access with the larger screen, though, and storing multiple trailer brake-gain settings is a cinch, so your priorities may differ.

I also don't miss the \$995 RamBox bed, which seriously diminishes the space available to carry bulk loads of mulch or

sand. In a truck that can carry nearly 2,500 pounds, the bed needs ample room to accommodate it. I am jealous of the \$295 RamBox Utility Group's handy cargo divider, however.

The EcoDiesel I sampled was in a 1500 Off the Grid SEMA Show vehicle equipped with Ram's new multifunction tailgate. That amazing piece of engineering is not yet available on the 2500 series, but as the most useful of today's crop of fancy tailgates, it should be.

Our first scheduled service stop is approaching. We'll cover that next time, and we'll don Guffman's winter coat (grille cover) to stay warm as he heads for northern Canada.



2020 Nissan Sentra



Service Life: 6 mo/4,203 miles
Average Fuel Econ: 29.9 mpg

"The Sentra seems to chant, 'I'm here, I'm average, get used to it!'" Claire Crowley

Avg CO2 0.65 lb/mi **Energy Cons** 112 kWh/100 mi
Unresolved Problems None **Maintenance Cost** \$0 **Normal Wear** \$0
Base Price \$21,195 **As Tested** \$24,800 **EPA City/Hwy/Comb Fuel Econ** 29/39/33 mpg **Real MPG** 32.1 mpg comb



Our Sentra excels at drop-off duty.

Still for the most part lounging close to home, our Sentra has logged just shy of an additional 2,000 miles since the ill-fated road trip we covered in a previous update. During its workaday routine of school drop-offs and pickups and trips to the grocery store, the Sentra logged a best-tank mpg of 27.9 and a worst of 24.3, coming in at an average of 26.0 mpg over that span. For real-world driving, that's not too far off the EPA's estimate of 29 mpg in city driving.

A few months back, our Sentra got a break from the daily slog for a trip to the track, where our test team put it through its paces. Not surprisingly, given the car's modest 149-hp I-4, the Nissan don't set the streets on fire with blazing acceleration. Our long-termer logged a leisurely 8.6-second 0-60 time. That's even slower than the Hyundai Elantra's 8.4 seconds and Toyota Corolla's 8.2 seconds, and it places the Nissan well behind the 2020 Honda Civic's 7.3 seconds. Associate road test editor Erick Ayapana commented that he achieved the best acceleration times in the Sentra using a brake-torque launch. Also known as a pedal-overlap launch, the driver keeps the car in place by putting a foot on the brake while using the other foot to rev the engine against the torque converter. It's doubtful that anyone in the market for a budget family sedan would use this drag race launch technique—or even know of it.

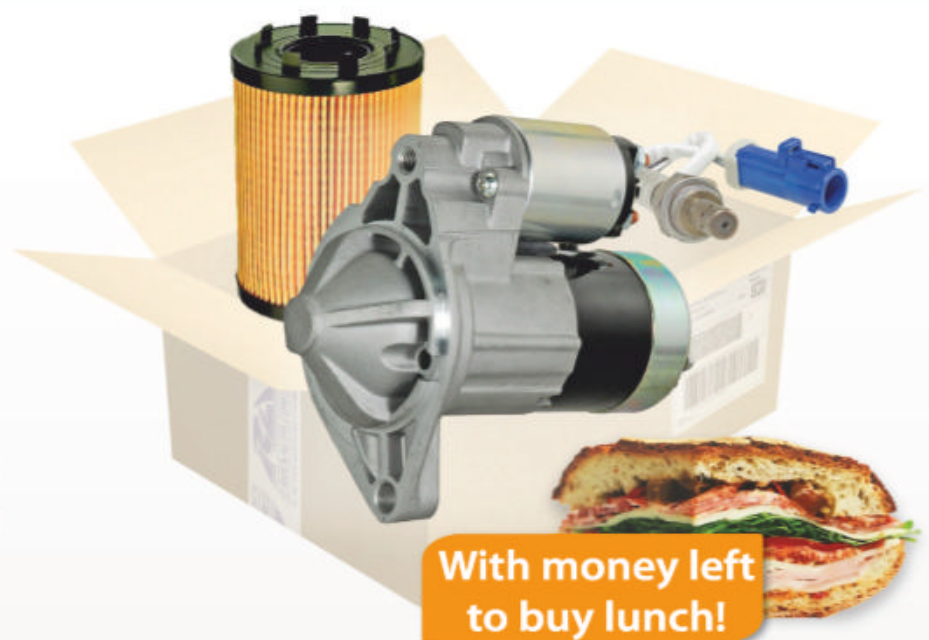
On the skidpad, our long-term Sentra performed as expected in the figure eight, completing the run in 27.5 seconds at 0.61 average g. Those results put it squarely in the same ballpark as the Mazda 3, Toyota Corolla, and Hyundai Sonata, which turned in times of 28.1, 27.8, and 26.6 seconds at 0.58, 0.59, and 0.66 average g, respectively. "There's nothing particularly good or bad about the Sentra on the figure eight," road test editor Chris Walton said. "It tends to understeer but is fairly neutral if it isn't pushed to the absolute limit." Walton did call out the Sentra's brakes, which started to fade after a couple of laps.

Ayapana seconded that opinion. During the Sentra's 60-0 braking tests, he noticed some "pretty dramatic distance creep." On the first test, the Nissan stopped from 60 mph in 122 feet. In three subsequent runs the distances crept their way up to 128, 128, then 131 feet. Although Ayapana thought the brake pedal had decent feel, he also noticed the brakes "never really got good bite." Its best braking distance puts it on par with its competitors.

Back home from the rigors of the track, the Sentra has been a reliable if not terribly exciting daily driver. It has settled into a groove of quietly and proficiently going about its work.



Get this with your money
at a typical auto parts store.



With money left
to buy lunch!

Or ALL this at
www.RockAuto.com!



- ✓ Reliably Low Prices
- ✓ Easy To Use Website
- ✓ Huge Selection
- ✓ Fast Shipping

“like a mirror”



When you get down to it, it's not what the manufacturer says about his product that counts, but what the customer says. And folks who tried this wax had a lot to say. "Magic", "blown away", "stunning" and yes, "like a mirror" are some actual customer descriptions. So, to all of you who have fallen in love with this amazing wax, we thank you heartily. To those of you who have not tried it, we hope you'll join the party and see what all the fuss is about. Learn more at p21s.com.

HORSEPOWER NOT REQUIRED



Our high performance spray tip works like a professional spray gun to make scratches virtually disappear. And with more than 300,000 OEM colors available you're sure to find the exact match for your vehicle.

Automotivetouchup.com
888-710-5192

MT GARAGE | Updates

2020 Honda Civic Si



Service Life: 5 mo/3,000 miles*

"People often assume you make compromises when driving a sporty car. Sometimes that's true, but not so with the Civic Si." Scott Evans

Avg CO2 0.65 lb/mi* **Energy Cons**, city/hwy 130/94 kWh/100 mi*
Unresolved Problems None **Maintenance Cost** \$0
Normal Wear \$0 **Base Price** \$26,130 **As Tested** \$26,130
EPA City/Hwy/Comb Fuel Econ 26/36/30 mpg



A lot of folks who aren't car enthusiasts tend to believe you're making a lot of compromises when you buy the sporty version of a car: miserable ride quality, useless rear seats, equally useless trunk, terrible fuel economy, and more. In some extreme cases, that's true. But not with the Honda Civic Si.

I grew up in a rural area on the other side of the mountain from Silicon Valley, but it was close enough to see the wealth that lived high in those hills. Back then, though, it was stealth wealth, at least to me. Sure, these people owned Ferraris, but they only took them out on weekends for a quick drive, a wash, and then back in the garage the rest of the week while the BMW or Mercedes did commuter duty. It was a shock to me when I moved to L.A., where rich people daily drive Ferraris. It's possible to use a purpose-built sports car as a daily driver and your only vehicle, but there are a lot of compromises that come with that decision. The inherent beauty of a well-designed sport sedan is that you make few if any compromises.

Honda used to offer the Si as a coupe but now only as a more practical sedan. No complaints here about climbing into the back seats—it has four full doors. Although compact sedans don't generally have the biggest back seats, this Honda's offers reasonable room for adults. In this class, that counts as excellent.

Likewise for the trunk. At 14.7 cubic feet, it's no pickup bed, but it's far more useful than the average compact SUV. Not only is the space large and generally square, but I also don't have to buy or remember to install a cargo cover to protect my stuff from prying eyes. Setting out for an extra-long weekend at a meticulously cleaned Airbnb with a pool, the Civic had no trouble swallowing a pair of coolers, suitcases, a

box of wine bottles, and miscellaneous bags and other things we forgot to pack until the car was already loaded. All without putting down the rear seats.

The excitement of an anniversary weekend around a private pool was in no way tempered by the thought of getting there. In some sporty cars, three hours on the freeway is three too many, be it because of the ride quality, interior noise, or the constant gas stops. An EPA-estimated 26/36/30 mpg city/highway/combined cures any worry of the latter, and the former two were no issue, either. I've talked before about the ride quality, particularly as it relates to when and where to use the Sport button next to the shifter. The highway is no place for it. In their default setting, the dampers are a little stiff for your average compact sedan, but they're quite nice for one that handles this well. Interior noise? Again, it's a compact sedan that's been made sporty, not a track car that's been tamed for the street. It's fine.

As expected, then, the drive out and the drive back five days later were a breeze. The front seats have bigger bolsters than your average Civic to keep you planted in hard driving, but they aren't thin, hard racing buckets; they still have ample padding. There are plenty of places to stash phones and other accoutrement in the multiple cubbies and shelves. Apple CarPlay lets you stream whatever music or podcasts you want, and there's a real volume knob to control what you're hearing.

The Honda Civic Si is a very fun little sedan. It comes alive on winding roads, but it isn't the walking dead every other day. It's still practical, comfortable, and efficient, but when you're ready, it's a credible sport sedan, too.

*COVID-19 interrupted our normal data collection for the Civic Si. Mileage is an estimate, and CO2/energy consumption figures are from the EPA.



2020 Mazda CX-30



Service Life: 7 mo/9,405 mi
Average Fuel Econ: 26.7 mpg

"On the open road, the CX-30 keeps its driver involved—too involved." Alex Leanse

Avg CO2 0.73 lb/mi **Energy Cons** 125 kWh/100 mi
Unresolved Problems None **Maintenance Cost** \$0
Normal Wear \$0 **Base Price** \$30,700 **As Tested** \$31,625
EPA City/Hwy/Comb Fuel Econ 25/32/27 mpg



Mazda no longer uses "Driving Matters" as its tagline (now it's "Feel Alive"—already do, thanks), but that ethos is still imbued in every one of its vehicles. We agree with that mantra—mostly. Sometimes we'd trade involvement for relaxation, particularly when enduring long highway stretches, as we've now done for several thousand road-trip miles in our CX-30. Turns out that when driving doesn't matter, this subcompact crossover is less than ideal.

As nice as the CX-30's accurate, reactive steering is on a twisty road, managing it becomes a chore when coursing dead ahead. Lane keep assist can be an awesome help in these scenarios, and the CX-30's spec sheet shows it as standard equipment. But on my recent drive between Los Angeles and San Francisco, it did basically nothing, providing such minimal help that I checked a few times to see if it was turned on. (It was.) Other than gentle nudges seemingly at random, lane keep assist would allow the car to drift across markers with nary a beep. Autopilot this absolutely isn't.

The CX-30 is also equipped with adaptive cruise control, which I came to call brake-check assist because of how committed it is to resuming its set speed after accelerating to pass. Instead of coasting down, the CX-30 brakes to reduce speed, causing some drivers I passed to brake in response. I'd have to override the car's action by applying throttle myself.

Eventually I started turning adaptive cruise control off when passing, lest other drivers think I had a bone to pick—all of which these systems are supposed to negate. At least the blind-spot monitors

effectively detect vehicles obstructed by the huge D-pillars.

Our logbook shows the CX-30 struggles to cover more than 300 miles between fill-ups. I eked out 317 miles at best, but photographer Darren Martin reported refueling every 280 miles or so on his hilly trek from Los Angeles to Oregon. Given its 12-gallon tank, the CX-30's approximately 25-mpg average isn't especially convenient for a subcompact SUV. Long-haulers might find the range frustratingly small, but I don't mind stopping to stretch about that often.

Thankfully, the driver's seat kept my stretch breaks from becoming lengthy vinyasa sessions. The CX-30's front seats don't look all that special, but they feel excellent, providing ergonomic support all down the back. Their padding is neither too firm nor too plush, insulating nicely against the busy ride. Cushy armrests and a leather-wrapped steering wheel made the CX-30 a nicer place to pass the miles.

On a solo road trip, the CX-30 was just spacious enough to fit my luggage in the passenger seat and my wheels-removed mountain bike over the folded-down second row. Fortunate that was, as my long weekend concluded with a trail ride in Santa Cruz. Carving toward the coast over forested Highway 17, the CX-30's pep and agility reminded me why driving matters. But afterward, drained and digesting a post-pedal burrito, I just wanted to chill. Little such luck—the Mazda's involving setup kept me overly wired for the next several hours.

Our experience indicates the CX-30 is better for around-town zipping than long-distance cruising. We'll see if that balance shifts as we pack on miles.

THE STEERING IS ACCURATE AND REACTIVE ON A TWISTY ROAD, BUT MANAGING IT BECOMES A CHORE.



H&R

100% Made in Germany



VTF Adjustable Lowering Springs

- For vehicles with original equipment electronic shocks
- Average lowering range of 0.30"-2.7"



H&R Springs, Coil-Overs, Anti-Roll Bars and More
www.tirerack.com/hr

FAST FREE SHIPPING

on All Orders Over \$50
www.tirerack.com/freeshipping

TIRE RACK
.com

888-372-8473

©2021 Tire Rack



47.1 cubic feet of cargo space (with the rear seats folded down). That edges out the Honda Civic hatchback (46.2 cubic feet) and allows plenty of room to haul everything from a mountain bike to a coffee table and a set of wheels. That said, our staffers had lots of comments about the cramped rear seats. The C-pillar likely contributed to the confined feeling, but the 35.1 inches of rear legroom was also a culprit; that's less than competitors like the Civic hatchback (36.0 inches).

Our fully loaded Mazda 3 was equipped with the Premium package and boasted an impressive list of creature comforts and technology. Memory seats and a head-up display, for example, are rare features in the segment, and the latter is quite good, rivaling ones found in brands such as Lexus and Acura. The excellent Bose sound system was another standout feature among staffers, as was the sharp infotainment display, controlled by an intuitive array of buttons and a rotary dial on the center console.

In addition to the aforementioned tech, the 3's thoughtful and well-crafted interior impressed us throughout its stay. The black and red color scheme was sharp, and the metallic brightwork, including the knurled HVAC knobs and brushed aluminum speaker covers, wouldn't look out of place in an Audi or Volvo. Interior door panels, the comfy leather seats, and other major touch-points showed little to no wear once we handed back the keys. Unfortunately, the same cannot be said about the piano black plastic trim surrounding the center console, which was frustratingly prone to scuffs and scratches from day one. Aside from that and the slightly loose center storage compartment lid, interior build quality was solid overall.

The Mazda 3 was also a staff favorite for road trips. Good ride quality and

Verdict: 2020 Mazda 3



"This curvy hatchback will make you second-guess that Audi or Volvo." Erick Ayapana

Base Price \$25,440 As Tested \$28,420

SPECS Options Premium package (\$2,980: head-up display, leather seats, moonroof) **Problem Areas** None **Maintenance Cost** \$288.06 (2: oil change, inspection, tire rotation) **Normal Wear** \$0 **3-Year Residual Value*** \$18,700 (66%) **Recalls** None

*IntelliChoice data; assumes 42,000 miles at the end of 3 years

Service Life: 14 mo/19,283 mi **Avg Econ/CO2:** 28.8 mpg/0.67 lb/mi

What a difference a year makes. We'll admit some of us struggled to immediately embrace the fourth-gen Mazda 3, which marked the automaker's pivot from its sporty image to a viable alternative to established luxury brands. But after 19,283 miles, we close a logbook filled with more praise than criticism.

Our Mazda 3 hatchback and its striking Polymetal Gray Metallic paint brought

a lot of style to the *MT* garage, which is key for an automaker that wants to be considered among luxury shoppers. A few staffers didn't fully embrace the 3's unique and thick C-pillar, but overall the hatch's sheetmetal is curvy, cohesive, and handsome enough to steal looks away from established luxury cars like the Mercedes-Benz CLA and Audi A3.

The Mazda served up lots of style with no sacrifice to practicality, providing us



The Mazda 3's driver's seat proved comfortable on long road trips, and with red leather everywhere, your eyes won't get bored.

Mazda has shifted focus from fun-oriented cars to a more premium space, but we still wanted to shift for ourselves.



minimal road noise at highway speeds were appreciated, while adaptive cruise control and the lane keeping setup worked as advertised. That said, we noted a few glitches from the driver assist systems. In one instance, the forward collision system activated and pumped the brakes during an early-morning commute on an empty and foggy road. And in some cases, adaptive cruise detected objects well outside of the car's path and abruptly reduced speed as a result. Hopefully Mazda can resolve these issues with a quick and easy software update.

Although the Mazda3 excels as a comfy commuter, it's more than capable and quite fun on curvy canyon roads. We opted for the six-speed manual transmission, which received mixed reviews from the staff. Some felt the clutch pedal was a tad too light and the shifter lacked the satisfying precision of ones found in the Civic or even Mazda's own Miata. Yes, we realize very few customers will opt for the manual, but those who do will be rewarded with a more engaging experience compared to the slightly lazy six-speed automatic. And thanks to the manual's more aggressive gearing, the otherwise adequate 186-hp 2.5-liter engine felt much peppier accelerating our 3,027-pound hatchback from a stop. Our observed 28.8 mpg is pretty much spot on with the EPA's combined rating of 29 mpg.

Aside from one flat tire and minor body damage sustained during a trip

to the snow, our 3 made it through the year with no other notable incidents. It required two routine service visits for an oil change, inspection, and tire rotation. Those visits totaled \$288.06, which is higher than comparable long-term vehicles we've had in the past. Our 2014 Mazda3 S GT hatch, for example, set us back \$162.55 for two visits, and our 2016 Honda Civic Touring sedan rang in at \$186.49 for its first two services. That said, Mazda's effort to upgrade its dealership experience appears to be working, as the one we visited looked upscale.

Despite relatively high service costs, our Mazda3's as-tested price of \$28,420 gets high marks for value considering the amount of style and tech you get for the money. It's proven to be a strong alternative to established entry-level luxury cars, and the recent addition of a turbocharged engine to the lineup makes the Mazda even more enticing.



THE 3 EXCELS AS A COMFY COMMUTER, BUT IT'S MORE THAN CAPABLE AND QUITE FUN ON CURVY ROADS.



VERDICT

2020 Mazda3 Hatchback

DRIVETRAIN LAYOUT	Front-engine, FWD
ENGINE TYPE	I-4, alum block/head
VALVETRAIN	DOHC, 4 valves/cyl
DISPLACEMENT	151.8 cu in/2,488cc
COMPRESSION RATIO	13.0:1
POWER (SAE NET)	186 hp @ 6,000 rpm
TORQUE (SAE NET)	186 lb-ft @ 4,000 rpm
REDLINE	6,500 rpm
WEIGHT TO POWER	16.3 lb/hp
TRANSMISSION	6-speed manual
AXLE/FINAL DRIVE RATIO	3.85:1/2.62:1
SUSPENSION, FRONT; REAR	Struts, coil springs, anti-roll bar; torsion beam, coil springs
STEERING RATIO	15.6:1
TURNS LOCK TO LOCK	2.8
BRAKES, F; R	11.0-in vented disc; 11.6-in disc, ABS
WHEELS	7.0 x 18-in cast aluminum
TIRES	215/45R18 89V M+S TOYO Proxes A40
DIMENSIONS	
WHEELBASE	107.3 in
TRACK, F/R	61.7/62.2 in
LENGTH X WIDTH X HEIGHT	175.6 x 70.7 x 56.7 in
TURNING CIRCLE	34.8 ft
CURB WEIGHT	3,027 lb
WEIGHT DIST, F/R	61/39%
SEATING CAPACITY	5
HEADROOM, F/R	37.5/36.5 in
LEGROOM, F/R	42.3/35.1 in
SHOULDER ROOM, F/R	55.7/53.4 in
CARGO VOLUME	20.1/47.1 cu ft
TEST DATA	
ACCELERATION TO MPH	
0-30	2.4 sec
0-40	4.0
0-50	5.5
0-60	7.4
0-70	9.8
0-80	12.3
0-90	15.5
0-100	19.0
PASSING, 45-65 MPH	3.9
QUARTER MILE	15.7 sec @ 90.6 mph
BRAKING, 60-0 MPH	115 ft
LATERAL ACCELERATION	0.85 g (avg)
MT FIGURE EIGHT	26.8 sec @ 0.63 g (avg)
TOP-GEAR REVS @ 60 MPH	2,200 rpm
CONSUMER INFO	
BASE PRICE	\$25,440
PRICE AS TESTED	\$28,420
STABILITY/TRACTION CONTROL	Yes/Yes
AIRBAGS	6: Dual front, front side, f/r curtain, front knee
BASIC WARRANTY	3 years/36,000 miles
POWERTRAIN WARRANTY	5 years/60,000 miles
ROADSIDE ASSISTANCE	3 years/36,000 miles
FUEL CAPACITY	13.2 gal
REAL MPG, CITY/HWY/COMB	28.6/43.7/33.9 mpg
EPA CITY/HWY/COMB ECON	25/35/29 mpg
ENERGY CONS, CITY/HWY	135/96 kWh/100 miles
CO2 EMISSIONS, COMB	0.68 lb/mile
RECOMMENDED FUEL	Unleaded regular

PERMANENT LIFETIME ENLARGEMENT? Liquids Work Faster Than Pills



Liquids absorb 98% and immediately goes into the body's system. Easy to use. Take with or without your favorite beverage.

Dr. Bross advises erection size can be 3 inches bigger and can have enlargement for a lifetime when you continue to take PRO+PLUS LIQUID. Men of any age can achieve the highest success rate in 1 to 2 months. Reach Your Maximum Potential.



Although liquid is shown to work faster than pills, some men prefer pills and PRO+PLUS ULTIMATE PILLS are an excellent alternative.



What a difference 3 inches makes I'm Brenda, My man takes the Pro+Plus Ultimate. Hear how he satisfies me. (888)242-0469

PRO+PLUS ACCELERATOR LIQUID or CREAM
Customers tell us the Accelerator can speed up the time it takes for male enlargement up to 50%. Easy to use. Works with any Pro+Plus formula. You can feel the benefits immediately. **FREE WITH ONE YEAR SUPPLY OF ANY PRO+PLUS FORMULA**

Super Formulas See **FREE Special Offer Online**

SEXCITER LIQUID
Excites women better than Spanish fly. A couple of drops mixed with or without her favorite beverage can increase libido.



ATTRACT-A-MATE
Human pheromone spray can make women desire you.

For more than 30 years Dr. Bross has satisfied millions of men. **Money Back Guarantee**

Call us about our products. We'll give you important information you can trust. Be careful of discounters and imitators that sell the same type of products on Amazon, Ebay and Google. Our products are not authorized to be sold through these companies. Don't buy from sellers who don't disclose where their products are made, use inferior blends and cannot call them.

PRO+PLUS XTREME
For Immediate Erections. Effective Up To 12 Hours. **Preferable alternative to the blue pill.**

Credit Card Orders Call Toll Free Anytime • 24/7

1-800-378-4689

Customer Service 1-707-931-1001

Se Habla Español



Mail Payment to:

Avid Pro Medical Dept. 16MAA
22287 Mulholland Hwy Box #416, Calabasas, CA 91302
☐ Check ☐ Money Order ☐ Cash

www.ProPlusMed.com

Pro+Plus Liquid or Pills ☐ Liquid ☐ Pills

Name (Print. I am over 18 and agree to the terms of ProPlusMed.com)

Address / City / State / Zip

Credit Card Number

Expires

CVC Code

PRO+PLUS XTREME

1 Bottle (5 Capsules)

1 Bottle 60 Capsules

PRO+PLUS ACCELERATOR LIQUID

PRO+PLUS ACCELERATOR CREAM

SEXCITER LIQUID to Excite Women

ATTRACT-A-MATE Pheromone to Attract Women

\$15.00

\$50.00

\$25.00

\$25.00

\$25.00

\$25.00

30 Days plus 30 Days **FREE**

60 Days plus 60 Days **FREE**

Dr. Bross Recommends One Year Supply To Reach Your Maximum Potential.

\$50 \$90 \$170

\$60

\$110

\$210

\$80

\$140

\$240

Shipping, Rush Service and Insurance \$20.00 VALUE ONLY \$ 14.95

Total Enclosed \$

Individual results may vary. These statements have not been evaluated by the FDA. This product is not intended to diagnose, treat, cure or prevent any disease. V161

Dramatic chip repairs are this easy!

BEFORE AFTER



1. Apply

2. Smear

3. Blend

Smooth Professional Repairs



"The Cure for Road Rash"

Rated #1 by The Wall Street Journal

DR. COLORCHIP
AUTOMOTIVE PAINT CHIP REPAIR SYSTEMS

ORDER YOUR KIT TODAY!

DRCOLORCHIP.COM • 866.372.2548



Stream the Best Car Shows.
Anytime, Any Device.

MOTOR TREND

Go to:

motortrend.app.link/mt

MOTORTREND Presents
TopGear
AMERICA



BBC
TopGear



A MOTORTREND ORIGINAL SERIES

ROADKILL

MOTORTREND

Stream All the Best Car Shows!
Go to motortrend.app.link/mt

Angus MacKenzie

The Big Picture



Tipping Point: But as the auto industry goes electric, not everything will change

The new world is almost here. By 2030 you won't be able to buy a new Bentley with an internal combustion engine. You won't be able to buy a Volvo with one, either. Nor, in Europe, a Ford. By 2030 Jaguar will have been an all-electric marque for five years, and Land Rover will be just six years away from its entire lineup being powered by either batteries or hydrogen fuel cells.

The end of the decade sounds a long way off. No more Rolling Stones gigs. The Cubs could win another World Series. The Tesla Model S will almost officially be a classic car. But in terms of designing, engineering, and building new electric cars, trucks, and SUVs, it'll be here tomorrow. We're no longer at the dawn of the electric automotive age. The sun's up, and people are hard at work on the most profound change to the automobile since Henry Ford put the world on wheels.

And it is profound. Volvo, for example, has just put all its internal combustion engine engineers into a separate business unit intended to provide parent company Geely with expertise in traditional powertrain technologies. That's right. A company whose engineers have been designing and building internal combustion engines in-house since 1927 no longer has anyone on the payroll with that skill set.

With huge capital demands and wafer-thin margins, the auto industry is not for the faint-hearted. Never mind the cost of entry; the cost of survival has kept out new players for decades now. But the hysteria around Tesla—which finished 2020 valued at more than VW, Toyota, Mercedes-Benz, and GM combined—suggests the automobile's electrification throws that old calculation under the bus. And a bunch of Tesla wannabes—Lucid and Rivian, to name but a few—are swarming to further disrupt the industry.

Volvo chief technology officer Henrik Green agrees the technology arms race unleashed by the new electric vehicle manufacturers and the emergence of tech companies into the sector challenges the auto industry's traditional ways

of working. "We see speed in development has taken over as the key differentiator," he says. But that doesn't mean the EV newcomers, unburdened by the legacy costs associated with building internal combustion engine vehicles, have an inherent advantage, Green insists.

The popular notion that electric vehicle powertrains mean simpler vehicle architectures that can underpin more types of vehicles and can be kept in production longer is wrong, Green says. "It's easy to fall into the trap that BEV platforms will be simpler and have longer model cycles," he says. "Traditionally, whomever could do the most vehicles on the same platform would win. But in this new world, if you make a platform and believe you can keep it the same for 10 years, you'll probably be dead in 10 years."

Although relatively straightforward to engineer, with much of its hardware—the central underfloor battery pack, the inverter, the motors—readily sourced from suppliers, the skateboard platform favored by many EV startups is an inefficient solution in terms of both weight and packaging, Green says. Far better, he argues, to integrate battery cells directly into the vehicle's body structure and use motors and inverters that are tailored to a vehicle's performance and packaging parameters.

Volvo's transformation to a pure EV maker will therefore rely on in-house expertise. The company already has its own battery lab, and it's about to start designing its own motors with integrated inverters. "We gain electrical efficiency," Green says. "We gain in space efficiency. We gain in weight efficiency. There are so many areas where we can still optimize what from the beginning looks like a fairly simple solution."

The bottom line, according to Green, is now that traditional automakers like Volvo and Porsche and Mercedes-Benz and GM are focusing on EVs, the startups are going to need very deep pockets to stay in the game. "Our conclusion is that doing a brand-new EV is not going to be cheaper than doing a brand-new internal combustion engine vehicle." ■

We're no longer
at the dawn
of the electric
automotive age.

Battery level
81%

Rivian R1T deliveries should begin this summer, making it the first electric pickup on the road—but certainly not the last.

